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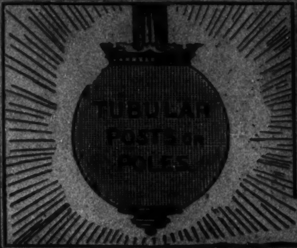

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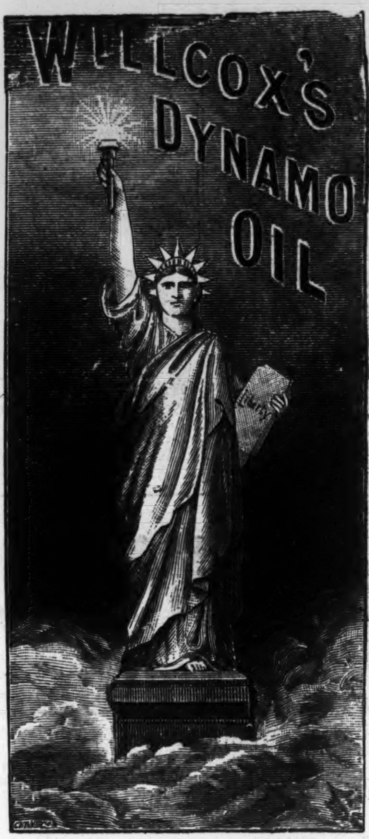

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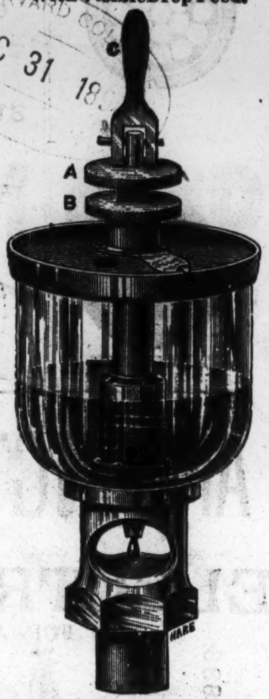

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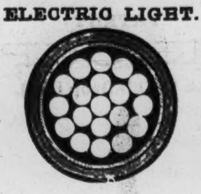

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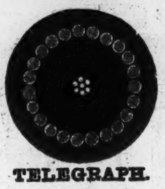

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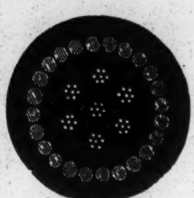

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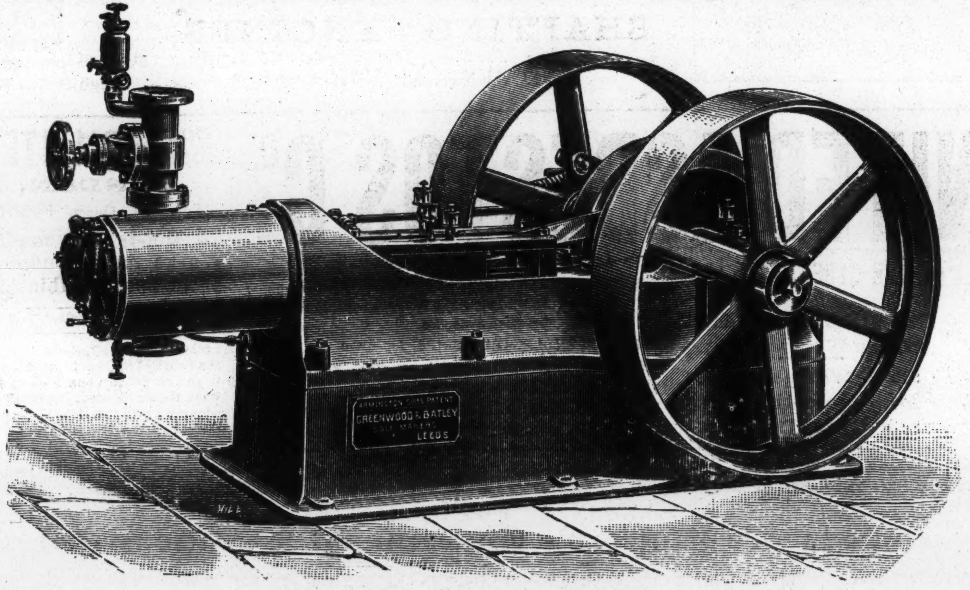

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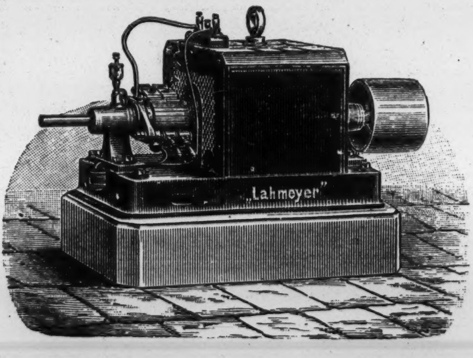

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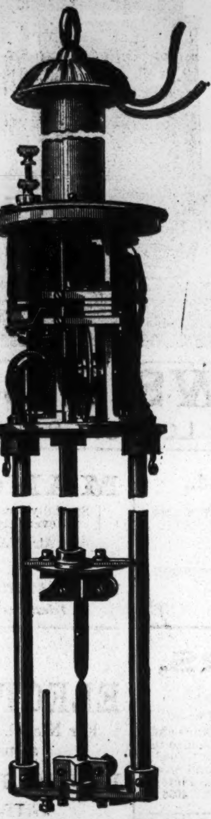

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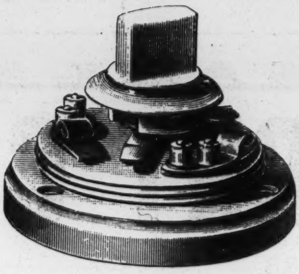

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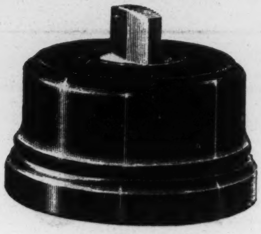

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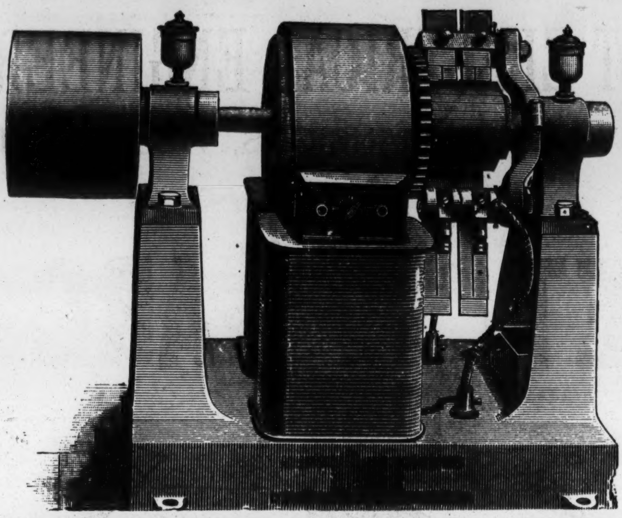

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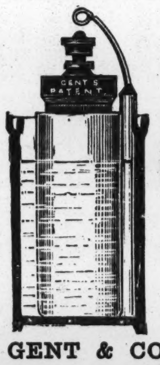

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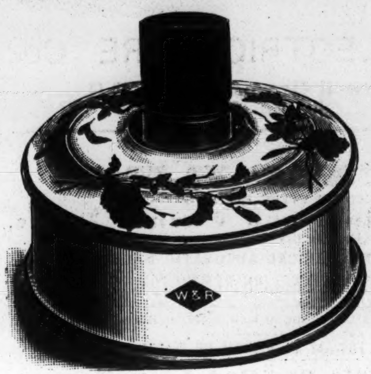

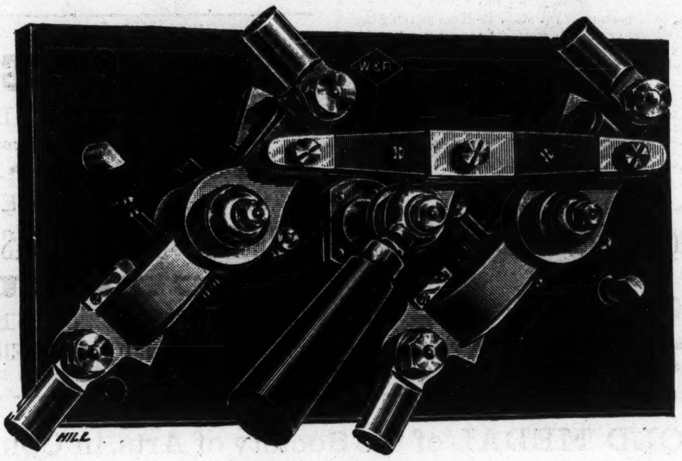

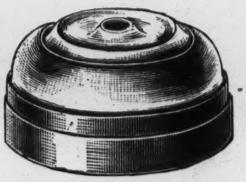

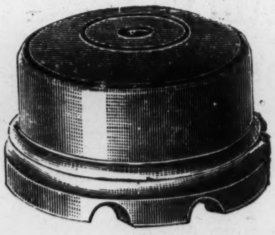

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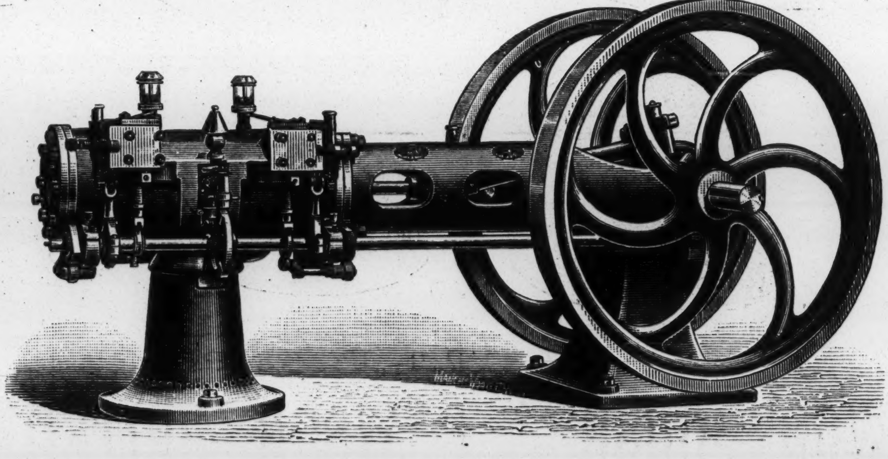

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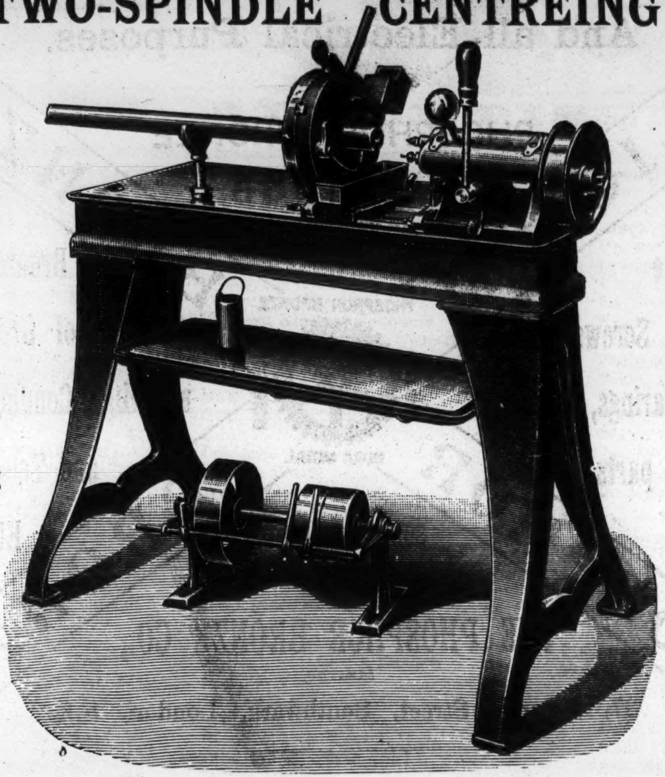

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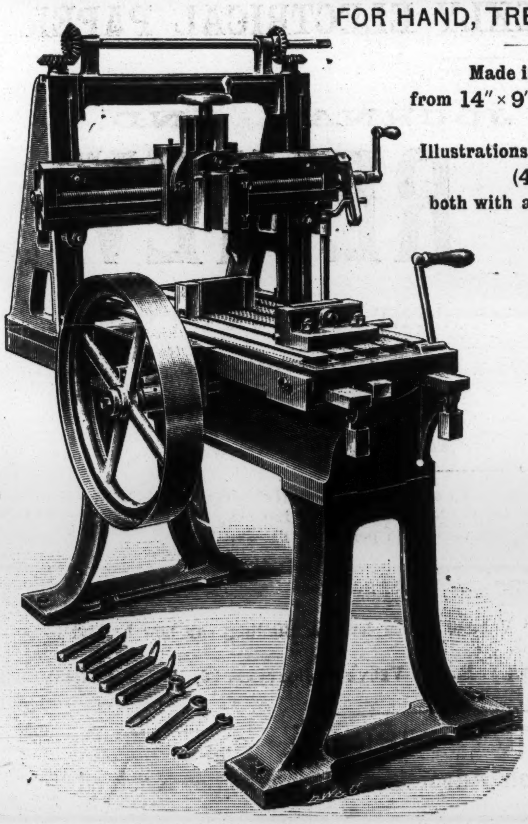

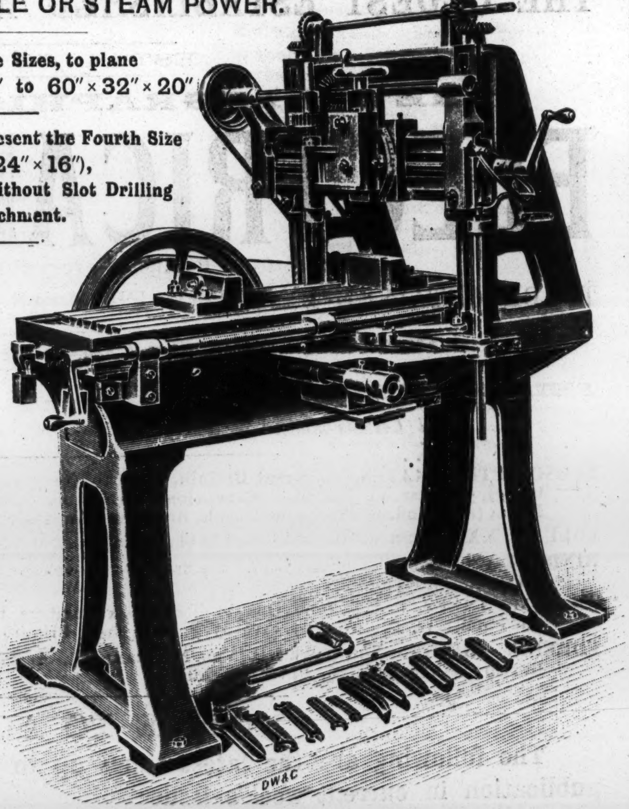

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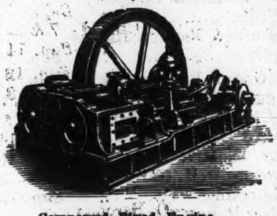

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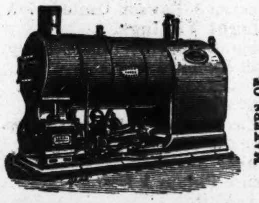

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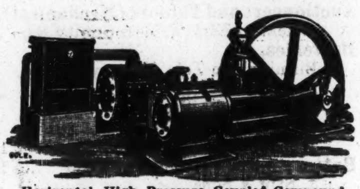

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DEC 31 1890

THE TELEGRAPHIC JOURNAL AND
ELECTRICAL REVIEW.

VOL. XXVII. DECEMBER 19, 1890. No. 682.

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ELECTRIC LIGHTING COMPLAINTS.

THE recent destructive fire at the Grosvenor Gallery station of the London Electric Supply Corporation, Limited, followed by a second disaster, which completely broke down the partially repaired transformers which had been previously damaged in the conflagration, has been the means of effectually stopping the supply of electrical energy to every customer in the district covered by the Corporation. How long this delay will continue we are unable to determine; but the misfortune which has befallen the supporters of the high tension scheme seems likely to be followed by a host of minor failures which will probably affect electric lighting companies generally. A glance at the columns of the *Times* reveals a state of affairs which does not, to a casual observer (that is if the Parliamentary question of Mr. R. Chamberlain, M.P., into the doings of a well-known supply company should be successful in throwing dust into the public eye), suggest that would-be consumers can yet place a proper degree of reliance in the *bonâ fides* of electric lighting systems. This gentlemen has taken it upon himself to ask in the House whether the attention of the Board of Trade had been called "to a long continued default of the Chelsea Electric Supply Company to furnish the statutory current of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence?" He also desired to know whether the Board of Trade would take steps to compel the company "to keep faith with the public, or forfeit their concession?" Mr. Irving Courtenay, the chairman of the Chelsea Company, in a letter which appeared in our daily contemporary on Monday last, completely demolishes, to his own satisfaction, Mr. Chamberlain's implied charges, but as his communication is directly followed by another from the M.P., reiterating his Parliamentary statements, the public may not easily be able to discriminate between the rights and wrongs of the matter at issue.

Mr. Chamberlain contends that the lamps supplied by the company are intended to be used at 100 volts terminal pressure, and he finds that, notwithstanding repeated complaints, he gets only 96 to 98 volts. He is apparently ignorant of the fact that the Board of Trade allows a variation above and below of 4 per cent., and it is on this point that the company justifies itself.

Mr. Chamberlain asserts that, with a pressure of, say, 2 to 4 per cent. below the specified voltage, he is left in semi-darkness; but in this he exaggerates, for Sir David Salomons has shown that for a loss of somewhat more than half the light, the fall in voltage must be about 10 per cent., whereas double illuminating power can be gained by an increase of 4 per cent. over the normal difference of potential. It is possible that the company might endeavour to keep nearer to the 100 volts for the sake of pleasing its customers; but, as we imagine the conditions under which supply is guaranteed are known to householders, it will be seen that the complaint, if any, should be directed not against the Chelsea Company but against the Board of Trade for having allowed so much latitude to suppliers.

There are other letters complaining of the uncertainty of all consumers getting current during the time when the London Electric Supply Corporation was generating electrical energy, but it is well known that in early days the demand was greater than the supply, and altogether we fear that the correspondence in the *Times* will have a damaging result upon electric lighting if some steps are not promptly taken to counteract its ill effects.

We have many times pointed out the difficulties which must be encountered in keeping the insulation of high-tension apparatus intact, and the interesting experiences of Mr. Gisbert Kapp, to which we refer in another column, completely bear out our contentions with regard to transformers. It will also be remembered that Mr. Ferranti's mains have come in for their share of criticism at our hands, and we cannot but think that the concluding remark in his letter (see our

Correspondence columns), with regard to his opinion on insulating materials, will not prepossess electricians in his favour, but, doubtless, the advocates of the insulator which he so ruthlessly puts aside will have something to say in its defence, although that is hardly required.

India-rubber has been tried and proven, although in some instances faulty design of leads, or ignorance of the precise purposes for which they were required, may have led to failure of insulation; but the Ferranti conductors have not yet been through that test of time which is necessary in order to show whether they confirm the views of their designer, or come to the end which has been prognosticated in other quarters. Mr. Ferranti's belief in his mains is unbounded, but he admits the difficulty of insulating both generators and transformers under an alternating difference of potential of 10,000 volts; now that work has been shut down for a time, would it be too much to ask the London Electric Supply Corporation to carefully consider its future, and to seriously entertain some modification in its high-pressure method, if that future is to be either technically or commercially successful?

The Corporation must not merely debate its own position *per se*, but it should give due consideration to the many firms whose work in wiring and fitting is largely dependent on the increasing number of its customers, for these contractors suffer as well as the public.

We have often urged that a failure, or even a partial stoppage of the Deptford works, would be disastrous to the electric lighting industry; we fear that the truth of our warnings, which were then disregarded, are beginning to make themselves apparent, and we would, as friends, also suggest to Mr. Ferranti the absolute necessity of thoroughly reconsidering his plans. He has now by sheer misfortune got the opportunity for which he has always asked, a period of inaction in which to bring every part of his producing and distributing plant into thorough order, and we trust that he will, notwithstanding a heavy secession of consumers, neither shorten the time that is necessary for perfecting his work, nor spare any effort which shall tend to render a repetition of the mishaps impossible in so far as human ingenuity can be sure.

To guard against men of Mr. Chamberlain's stamp, we would strongly advise electric light companies to hold as near to their undertakings as possible, and not to merely keep within the limits of the percentage allowance. Judging from the eulogistic terms in which some supporters of the Kensington House-to-House Electric Supply Company speak, it is not a serious matter to give customers exactly what they expect and to which they are entitled.

High-Pressure Alternating Mains.

FOLLOWING the reading of Mr. J. Swinburne's paper on "Alternating Current Condensers," at the Physical Society, there was a discussion which drifted from the subject of the paper into a speculation on the alleged rise of E.M.F. in the Ferranti mains. Prof. Ayrton stated, and he was supported by several other speakers, that the difference of potential taken from a transformer at Deptford was 80 volts, whereas at the Grosvenor end it measured 100 volts. This enormous rise seemed inexplicable, and various theories were advanced with a view of accounting for the possibility of such a phenomenon. Prof. Ayrton referred to a conversation he had had with Mr. Ferranti, which revealed the fact that no direct measurements were made at the termini of the mains themselves, and it has occurred to us since that there might be an error somewhere, and it would be both instructive and interesting if the low-tension transformers at both ends were transposed, viz., the Deptford one to Grosvenor, and that of the Grosvenor to Deptford, and fresh measurements made. We have an idea that the results would then turn out differently, since it is just possible that the transformers themselves may be to blame for this variation; they do not always give that which they are "calculated" to produce, and it seems hardly credible that there could be an unexpected rise of 25 per cent. entirely due to inductive effects; the dimensions of both transformers, we assume, being similar. Mr. Kapp related an interesting experience of his own, when he fruitlessly endeavoured to transform 1,000 into 14,000 volts; he failed entirely in the attempt, in spite of all ordinary care with insulation, the high tension transformer breaking down in every case in a remarkably short space of time. Every day it seems to become more certain that the 10,000 volt craze is giving way, and it seems a great pity that several hundred thousand pounds should have been spent in proving that which could have been as conclusively shown with as many shillings.

Experiments with Selenium Cells.

THE last meeting of the Physical Society was unusually attractive. Mr. Shelford Bidwell, F.R.S., told us a great many useful facts about selenium cells and their behaviour, and he gave several experimental illustrations, the most effective of which points to practical applications. Mr. Bidwell connected one of his selenium cells with a delicate relay, which in its turn caused circuit to be established with an automatic switch and an electric lamp. So long as sufficient light impinged upon the selenium the electric lamp did not act, but directly the gas (or daylight in practice) diminished to a certain degree the electric lamp shone forth in its glory, and again became extinguished when its rival reappeared. The fact of any light going out could thus be signalled to a distant attendant, and this would be useful in case of ships' lights and numerous other purposes. The effect of different coloured glass interposed between the light and the cell revealed peculiar results upon the properties of the selenium, and Dr. Thompson suggested that one could almost imagine the near possibility of seeing by electricity if the effects of colours could be transmitted to distances in some analogous manner.

Professors on the Technical Press.

PROF. AYRTON, at the Institution of Electrical Engineers, gave his reply to the various points raised during the discussion of the papers on Secondary Batteries. We give an abstract of this reply, and we only refer here to certain remarks which fell from the professor's lips about scientific journals. His attention being called to a letter which Mr. Swinburne wrote to a contemporary a few years ago, Prof. Ayrton said that he could not be expected to read all the matter in an electrical journal, considering that he had scarcely time to attend to his own correspondence, but almost in the same breath he opened a mild attack upon a leading article on Secondary Batteries which appeared in the ELECTRICAL REVIEW on the 25th July last. Prof. Ayrton devoted so much time and attention to this article that we shall discuss at an early opportunity the questions touched upon at last Thursday's meeting.

Unsatisfactory Work and its Results.

THAT misfortunes never come singly has been amply shown by the lamentable results of the recent fire at the Grosvenor Station; and even this is supplemented by a serious accident which has occurred at Nancy (France) where the Ferranti system is in use. In this case a horse was instantly killed through receiving a shock, whilst the rider or driver also received a shock, and had to be conveyed to the local hospital. The E.M.F. of the alternators was 2,400 volts, but the accident was not caused by the system employed, it being due to the loose method in which it had been carried out. The cables used are concentric, insulated with jute and hemp, and laid directly in the ground. Where branches and connections to subscribers are made, cast iron boxes, laid from 20 to 24 inches deep, are provided, and after the connections have been made the boxes are filled with *brei*, which is a kind of tar. Since the station was started the insulation of the cables has been found to be defective, and numerous "earths" have taken place—and no wonder. Now that a horse has been killed, and a man seriously injured, the Nancy authorities are investigating the causes of the accident.

Oil Engines.

IT is somewhat difficult to understand how oil or gas engines can be conveniently and economically employed for traction, tramcar, or fire engine purposes. Yet, of the three latest oil engines introduced, the makers of two of them state that their engines are very suitable for such purposes. In this connection an industrial contemporary (usually above suspicion), when describing a new oil engine a few weeks ago, actually reproduced the maker's statement to the above effect. It is, however, satisfactory to note that in the description last week of a new oil engine, for which such claims are put forward by the maker, our contemporary wisely refrains from giving them publication.

The Rubicon Passed.

THE feverish excitement which followed the floating of the Anglo-American Brush Electric Light Company is now past history, though doubtless there are still many victims who have reason to deplore their folly in attempting to become wealthy by a stroke of the pen. Though the fever is no longer violent, it still shows fitful signs of being in existence, but it is steadily diminishing, and a healthier state of things has resulted. Amusing accounts which used so frequently to come to hand of people's ideas of the electric light are no longer met with; even in the most out-of-the-way places a fairly just estimate of the commercial value of the electric light seems to be arrived at, the inevitable result being that sound trade is becoming brisk and prospects of a brilliant future for electric lighting daily become more certain. The powers being sought for by several municipalities for carrying out electric light work themselves are certain to lead to others following in their steps, and must lead to the employment of many electrical engineers, of whom there is not likely to be any dearth. The last 10 years has been not altogether an encouraging time, but those who have had the patience and stamina to hold on are now likely to reap their reward.

Lamp Rheostats.

OUR American contemporary, the *Electrical World*, in describing an arrangement of lamp socket, by which, on turning the switch, the amount of light obtainable can be graduated by successive steps, as in an ordinary gas burner, makes the statement that the amount of heat developed (in the graduating resistance) after an hour's burning is not so great as to render the socket unbearably warm, so that it will be seen *that the loss through heat waste has been reduced to a minimum.* It is perhaps almost unnecessary to point out that this notion is an utter fallacy, the amount of heat generated in any case is an invariable quantity, and because it is *masked*, as it were, it none the less exists. The users of incandescent lights have often asked, "Can you not furnish us a light which is capable of being turned down just as gas is?" We believe in most cases the object of the consumer in asking for this is not so much to diminish the light as to effect an apparent saving in money. Probably if he knew what a very small diminution in energy is saved when the illuminating power of a lamp is cut down to, say, one-half, he would not consider it worth while to have the contrivance he asks for, though there are cases, of course, where it would be useful.

Heavy Dividends Coming.

THE electric light companies of London must soon report progress to the Board of Trade; that is, they must take stock of themselves up to the last day of this month. It is said that there will be no dividends; but shareholders are not to trouble on that score, for it is believed that the companies have almost reached that point after which their receipts will be almost entirely clear profit. In other words, the cost of producing electrical energy for, say, double or treble the present number of lights, will be so little increased in proportion, that the income derived from future customers will be almost wholly available for making the fortunes of stockholders. This, at all events, is the purport of a long article in the *World* of Wednesday, and we must congratulate Mr. Edmund Yates in being able to place the subject so temptingly before his readers, many of whom will doubtless rise to the bait. Even if they do not move a yard beyond the present areas allotted to them, says our contemporary, the companies ought to make enormous fortunes over and over again before the end of their 42 years. We only hope they may.

Simple as A B C.

FURTHER on the *World* endeavours to show that electric lighting is so simple that the notion that there is something specially dangerous in it is sheer delusion. "You may, if you like, easily blow up your house with gas; the utmost mischief you can do with your electric wires is to spoil them." "The current is so weak when it enters your house that a baby may play with it." "What danger there is exists only at the central stations or at the subsidiary stations where the current is 'transformed' for customers." "The only damage to which customers are liable—that of being left in sudden darkness by an accident to the wires—is being obviated by double machinery and by connections between subsidiary stations." The *World's* electrical contributor makes things look bright commercially, but when he rises to technical points his remarks make one feel sad to think that there is so little to learn after all these years of study.

THE EXPERIMENTAL DEMONSTRATION OF VALENCY BY ELECTRICITY.

IT is impossible to proceed very far in the study of physics without trespassing upon the domains of the sister science, chemistry. Indeed, many of the most interesting questions which to-day engage the attention of scientists lie just on the borderland, as it were. The knowledge which has been acquired respecting the character of the "atom" and the "molecule" is entirely of a physico-chemical nature, and the pursuit of more knowledge respecting these obscure entities—if such they be—necessarily involves the services of the disciples of both sciences.

Leaving generalities, let us take a particular case. No electrican can hope to fully understand all that has been learnt respecting the internal working of a galvanic battery, much less can he hope to advance knowledge in this direction unless he have at least grasped the principles of the science of chemistry, and has made himself familiar with the various reactions and decompositions which are likely to result when substances are placed in intimate relation. And we take the opportunity of urging all such as are engaged in those departments of electricity which are concerned with the use of batteries, &c., to combine with their electrical knowledge a knowledge of the leading outlines of chemistry at the very least.

Most of our best electricians are tolerably good chemists. Few discoveries are now made *accidentally*; they are the result of intelligent, organised work and laborious investigation. There is, therefore, the greater need for thoroughness.

We have written in this strain more by way of apology than with the idea of leading up to a directly-interested question, although partly to introduce something which is perhaps of a more distinctly chemical than of an electrical nature.

Our readers may remember an illustrated article which appeared in our issue for October 24th on the subject of the action of the electric arc upon gaseous substances. The apparatus therein described may be utilised in order to demonstrate a most important matter in chemistry. And we commend it to the notice of such of our readers as have already embarked upon the right course, and combined with their knowledge of physics some knowledge also of the sister science.

In studying chemistry we are soon confronted with mysterious symbols which, to the uninitiated, are simply bewildering; but we soon find out that they are the "short-hand" of the science, and, moreover, that they assist us to perceive, and, if necessary, to explain, with great rapidity, matters which would otherwise be difficult to grasp.

Chemical formulæ, or symbols, are, to a great extent, based upon certain assumptions regarding those properties of atoms which are referred to under the name *valency*. It is found that the atomic weight of an element is, in some cases, equal to its combining weight, whilst in others it is twice, three times, four times, &c., as great. In other words, an atom of certain elements can be substituted for, or can replace, only one atom of hydrogen, whereas the atoms of other elements can replace 1, 2, 3, 4, &c., atoms of hydrogen. This difference of saturating, or combining power, called by the older chemists atomicity, is now appropriately termed valency.

The meaning of this term is rather difficult to explain experimentally; according to Lepsius, in a recent paper in the *Berichte der Deutschen Chemischen Gesellschaft*, the apparatus shown in the article which we have already referred to (see page 482) can be used with great success for illustrating this peculiar property of the element.

Four such apparatus of dimensions, each 35 mm. in diameter and 150, 200, 250, 300 cc. capacity respectively, are so arranged that the uppermost stop-cocks are all at the same level. They are then filled with equal volumes, say, about 100 cc. of the following gases: Hydrogen iodide [HI], hydrogen sulphide [H_2S], hydrogen phosphide [H_3P], and hydrogen carbide (methane) [H_4C] respectively, the volume being marked on the tube immediately after the introduction of the gas.

The arc is now ignited by turning on the current in each of the four apparatus, either separately or simultaneously; this decomposes the gases into their several elemental constituents. They are then allowed to stand at rest for some time in order to allow the contents of the tubes to cool and the pressure therein to become adjusted. When these conditions are fulfilled the volume of the liberated hydrogen in the four tubes is seen to be in the ratio of

$$1:2:3:4$$

showing that the formulæ given above correctly express the relations of the constituents of the substances experimented on; in other words that iodine is monovalent, sulphur is divalent, phosphorus is trivalent, and carbon is tetravalent.

This apparatus may be advantageously used for lecture demonstrations.

SOME FACTS CONCERNING GUTTA-PERCHA.

(*Continued from page* 708.)

THE third phase of the second of the two periods into which the history and investigation of gutta-percha are divided, is indicated by the explorations of M. Burck, the director of the botanical gardens at Buitenzorg.

The report of M. Seligman-Lui, on his return to France, impelled the French Government to ask the permission of Holland for the dispatch of a properly equipped expedition to explore Sumatra for the purpose of obtaining gutta-percha plants, with the object of attempting their cultivation in Cochin-China. This request was not granted, and the reason given for the refusal was that the natives of the interior, the Bataks, were divided into many tribes perpetually at war with one another, and the Government could not allow itself to be placed in a position of moral responsibility towards travellers over whom it could exercise no protecting influence. Strangely enough, at this very moment, M. Burck received instructions from the Dutch Government to undertake precisely the same investigations. It is to be presumed that the Bataks were then temporarily at peace with one another.

During the course of his explorations M. Burck observed 14 varieties of gutta-percha trees, among which he was only able to select two having any useful properties. These were the *Niatouh balam tembaga*, from Ampaloo, a species he described as being new, and giving a gum of excellent quality, and the *Payena Leerii*, well known already, and supplying a gum of second class quality.

The other specimens belonged to the following varieties:—

Tembaga, from Halaban.

Bringin and *Tembaga*, from Soupayang (the Bringin is nothing else but the Payena Lerii).

Dourian, from Halaban and Kayon Tanam.

Pissang, from Halaban.

Bindalou, from Halaban and Sagoh mountain.

Selindit Pipit, and three varieties of *Niatouh balam*, from Pouar-Dastar, Labouéï, and Ampaloo.

Niatouh balam, from Glougour.

M. Burck brought back to the museum in Java the flowers and gum from the *niatouh balam tembaga*, but throughout the forests situated between Sialang and Glougour he only succeeded in discovering one adult growing specimen of this tree. He found, in every direction, nothing but large trunks lying where they had been cut down, and the natives assured him that the same condition of affairs existed in the districts of Sidjounjoung. It took M. Burck a whole week to find the single specimen above referred to, and the forests he explored were very little frequented, and have only recently been taken possession of by the Dutch Government. Some 75 young plants of the *niatouh balam tembaga* were obtained, and sent to the garden at Buitenzorg.

M. Sérullas proceeds to give an account of the circumstances which led to his investigations in search of a better variety of gutta-percha than discovered by late explorers, the idea of the French Government being to create a nursery at Saigon, so as to perpetuate, by cultivation, the better classes of percha so rapidly becoming extinct. No specimen of the *Isonandra* had been met with for more than 30 years, and the claims of the Buitenzorg gardens to the possession of young plants of that species were easily disproved. The plants obtained from the English and Dutch authorities were not of a suitable class, and those collected by M. Seligman-Lui had been lost.

The author, during the course of long exploration, met with a considerable number of adult trees of the *taban merah* and *taban soutra* among the forests frequented by wild and independent tribes on the Malay peninsula. Suffering from severe attacks of fever, M. Sérullas was compelled to seek relief in France, but, restored to health, he speedily returned to Malaysia, and, after much difficulty, succeeded in transporting to Singapore a number of the young plants of the two species above mentioned. While awaiting the decision of the Government of Cochin-China as to the disposal of the plants, M. Sérullas, greatly to his astonishment and delight, discovered *bona fide* specimens of the *Isonandra gutta Hookerii* in the ravines of Boukett Timah, in the interior of Singapore. This was indeed a fortunate chance, since for forty years the *isonandra gutta* had been searched for in vain.

On the communication of this discovery to the Governor at Saigon, the order for the transport of the young plants of the *Taban Mérah* and *Taban Soutra* was revoked, and instructions given to send to Saigon the plants of the *Isonandra.* This was done, but notwithstanding all the careful advice given by M. Sérullas as to the treatment of the shoots, they were allowed to perish through want of attention. The seeds of the *Isonandra* were then obtained, and sent to Saigon, but M. Sérullas, in obtaining these seeds, became affected with chronic dysentery of so violent a form as to necessitate his return to France. His mission was abandoned, and the French Government ceased to give the matter any further attention. The young plants of the *taban mérah* and *taban soutra* were left in the gardens at Singapore.

In attempting to arrive at some practical conclusion as to the results of the explorations undertaken by Government officials, M. Sérullas points out the errors into which many investigators have fallen. It has been too generally believed that there existed a particular and defined substance, possessing certain especial chemical characteristics, called *gutta-percha,* and all endeavours have been directed to the search of its vegetable source. Instead of looking for a tree whose coagulated sap assumed the form of a gum endowed with all the qualities required in the most delicate applications, the investigators devoted themselves to the elucidation of botanical problems, and to the discussion of questions of nomenclature and botanical classification. To M. Seligman-Lui may be given the credit of directing enquiries into the proper channels. The only type of gutta-percha possessing the necessary attributes, the *Isonandra,* was to be found in Singapore alone, and had not there been met with for more than a third of a century; under these conditions, it was not the same tree which should have been searched for, but a gutta-percha gum analogous to that supplied by the *Isonandra.*

But if the questions regarding trees producing gums of little value, where submarine telegraphy is concerned, are put on one side, it may be assumed that during the second period, that of official explorations, the question has received practical solution. Adult trees producing good guttas have been found; gums, together with botanical specimens, have been obtained from these trees, and it is known where to find them.

The only trees in Malaysia supplying a sap whose coagulation gives a thoroughly good gutta-percha are :—

The *Isonandra percha* or *Isonandra gutta Hookerii,* from Singapore; the *Gueutta-taban mérah,* of Malacca; the *Niatouh balam Tembaga,* from Ampaloo (Halaban), Sumatra; the *Mayang-taban dourrian,* of Singgaloungan (Assahan), Sumatra; the *Gueutta-taban soutra,* from the Malay peninsula; and, finally, a tree, to be described later on, which differs but slightly from the preceding varieties, and whose trunk is supported by numerous aerial roots.

M. Sérullas states that the foregoing trees are not of different species in a botanical sense; that no considerable difference exists between their respective guttas; and that they may be considered as varieties of the same species.

The following methods for distinguishing in the forests these varieties from among other gutta-percha producing trees are practical, and are to be absolutely relied upon; (1) all sap which is a gutta-percha of the best class coagulates almost immediately it escapes from an incision made in the bark. This solidified sap becomes a stiff gum, much veined upon cooling after handling in hot water for two or three minutes.

(2) The leaves of these isonandra are covered on the under side with a fine, soft, and golden down in young plants and in fresh shoots. Later this down often becomes copper-coloured, and it sometimes disappears altogether in the old branches of large trees. Every isonandra, however, whether old or young, will have many leaves either gold or copper-coloured underneath.

(3) Every normal leaf presenting the foregoing features, and coming from a tree whose sap behaves as above indicated, will be found to have on each side of the principal vein from 22 to 35 very delicate and scarcely visible secondary veins; they are completely buried in the cellular tissue.

The preceding characteristics are only to be simultaneously found in the species isonandra, and the tree in which they appear may be relied upon to produce a gutta-percha of the best quality.

(*To be continued.*)

THE ELECTROLYSIS BY IGNEOUS FUSION OF FLUORIDE OF ALUMINIUM.*

By M. ADOLPHE MINET.

IN the two notes† which I have had the honour of presenting to the Academy, I showed that I had produced aluminium by the electrolysis of its fluoride in a melted state.

More recent experiments have enabled me to arrive definitely at the composition of the electrolytic bath, which for given values of the *temperature* and *density* of the current at the electrodes, corresponds to the best rendering obtained from the compound experimented upon; I also succeeded in determining the physical properties of the mixture of the salts in fusion, and establishing the formula which connects the constants of the current with those of the electrolyte at various periods.

Composition of the bath, its properties and its regeneration.—The bath is composed of a mixture of chloride of sodium and double fluoride of aluminium and sodium, corresponding to the chemical formula, expressed in equivalents :

$6\,Na\,Cl + Al_2\,Fl_2, 3\,Na\,Fl$; melting point, 675°; boiling point, 1,035°; density at 820° : 1·76; coefficient of dilatation in a melted state, 5×10^{-4}. Electrical conductivity at 870° : 3·1. The electrical conductivity, as a function of the temperature, is calculated by the equation :

$$c_t = 3{\cdot}1\,[1 + 0{\cdot}0022\,(t - 870^\circ)]$$

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* *Comptes Rendus de l'Academie des Sciences.*

† *Comptes Rendus,* February 17th, and June 9th, 1889.

For a current having an intensity of 1,200 ampères, the mass of the bath is represented by a weight of 20 kg. In this case, the density of the current (intensity per square centimetre of active surface), at the positive pole is 1 ampère, the difference of potential is 5·5 volts at the electrodes. The composition of the bath is maintained constant, during the decomposition of the fluoride of aluminium by means of the following mixture. Hydrate of alumina partly dried:

$$6\ [Al_2\ O_3,\ 2\ H_2O] = 416{\cdot}4.$$

Double fluoride of aluminum and sodium:

$$Al_2\ Fl_3,\ 3\ Na\ Fl = 210{\cdot}4$$

Oxifluoride of aluminium:

$$Al_2\ Fl_3,\ 3\ Al_2\ O_3 = 238{\cdot}4.$$

This mode of alimentation enables the two-thirds of the fluor given off at the positive pole to be replaced.

The bath is kept at the same level by the introduction of a mixture of chloride of sodium and double fluoride of aluminium and sodium, in the proportions given above.

Relation between the constants of the current and those of the electrolyte.—This problem resolves itself into two parts. Let ε be the difference of potential at the electrodes; e the electromotive force of decomposition; ρ the resistance of the electrolyte, that of the electrodes being disregarded; I the intensity of the current; δ the maximum density of the current at the electrodes, for each period studied.

A.—*The salts composing the bath are chemically pure.*

a. First period, from the point when the density of the current at the electrodes is equal to zero, to the point when it is such that the electromotive force of polarisation is of the same value as the electromotive force of decomposition of the electrolyte under consideration. For the lowest points, the difference of potential may be expressed by the relation $\varepsilon = K\ I$, the temperature remaining constant. Towards the limit of density, the value of the difference of potential cannot be calculated by a simple formula; I have, however, in certain cases, been able to determine the formula required. For a temperature of 870°, the maximum density of the current at the electrode, corresponding to the first period of the electrolysis of the bath experimented upon, varies between ·02 and ·03 of an ampère.

β. Second Period.—From the moment when the electromotive force of polarisation is equal to the electromotive force of decomposition of the electrolyte under consideration, to the moment when the density of current at the positive pole, with our bath of fluoride, reaches the value of 1 ampère, the difference of potential is expressed by the equation $\varepsilon = e + \rho\ I$.

These are the actual figures of the experiment:—

Temperature 852°. $e = 2{\cdot}15$. $\rho = {\cdot}01$.			Temperature 890°. $e = 2{\cdot}4$. $\rho = {\cdot}0044$.			Temperature 980°. $e = {\cdot}34$. $\rho = {\cdot}0033$.		
	ε			ε			ε	
I. amp.	Measured volts.	Calculated volts.	I. amp.	Measured volts.	Calculated volts.	I. amp.	Measured volts.	Calculated volts.
130	3·50	3·45	196	3·26	3·26	572	4·23	4·23
150	3·70	3·65	403	4·12	4·17	650	4·48	4·48
175	3·95	3·90	585	5·05	4·97	910	5·30	5·54
215	4 30	4 30	885	6·18	6·29	1,030	5·78	5·74
245	4·60	4 60	...	...	...	...	...	...

The density of the current at the negative pole is only limited by the dangerous heating due to the passage of the current.

γ. Third Period.—For densities of current above 1 ampère, the value of the difference of potential can no longer be calculated as a function of the intensity by a simple formula. It rapidly attains a value approaching that of an electric arc, or from 30 to 40 volts.

B. The electrolyte is mixed with certain proportions of foreign salts; salts of iron and of silicium in the case we are discussing. When we keep the density of the current at the positive pole within certain limits, these salts are decomposed according to Sprague's law. These are the figures obtained with a bath from which the salts of iron and of silicium were successively eliminated.

Temperature 810°. (Salts of iron.) $e = {\cdot}75$. $\rho = {\cdot}0093$.			Temperature 840°. (Salts of silicium.) $e = 1{\cdot}37$. $\rho = {\cdot}0089$.			Temperature 870°. (Salts of aluminium.) $e = 2{\cdot}15$. $\rho = {\cdot}0085$.		
	ε			ε			ε	
I. amp.	Measured volts.	Calculated volts.	I. amp.	Measured volts.	Calculated volts.	I. amp.	Measured volts.	Calculated volts.
75	1·45	1·45	65	1·95	1·95	100	3·00	3·75
147·5	2·20	2·11	137·5	2·65	2 61	130	3·28	3·00
225	2·85	2·85	217·5	3 35	3·31	187·5	3·75	3·25

It is to be remarked that in these last experiments the resistance, ρ, of the electrolyte remained constant, the composition of the bath of fluoride of aluminium being as indicated at the beginning of this note; the salts of iron and silicium, which discoloured it, were in very small quantities.

We have also some observations to make with regard to a method of analysing the bath, to the apparatus for measuring the temperature and the electric current, to the phenomena that are observed when, after the passage of the current, the electrolyte re-acts as a secondary battery. These points will be treated in subsequent notes.—*Comptes Rendus*, October 27th, 1890.

THE COMPLEX NATURE OF ELECTROLYSIS.

FARADAY applied the term *electrolyte* to those substances which, like hydrochloric acid, are resolved into their elements by the passage of an electric current. To the act of decomposition by the voltaic battery he gave the name *electrolysis*. In most cases, if a liquid permit the passage of a current of electricity through it, it is decomposed by the conductor, or, in other words, most liquids which possess conductivity are also electrolytes. Of course there are exceptions to this rule; some liquids, such, for instance, as alcohol and ether, although they are not absolutely non-conductive, are not capable of being decomposed by the passage of a current. The number of these apparent exceptions to the rule is becoming more and more limited as time goes on and they become better understood. Once people thought that acidulated water was the only liquid which could conduct the electric current; but now it has been proved that a vast number of binary and ternary, and even more complex substances, are amenable to the general law.

The decomposition of a binary substance like hydrochloric acid ($H\ Cl$) is comparatively simple. One of the elements goes to the positive and the other to the negative pole.

The decomposition of a ternary salt is more complex. It was formerly explained by saying that the acid was liberated at the positive electrode and the base at the negative. Thus sodium sulphate, $Na_2\ O\ SO_3$, was considered to be resolved into sulphuric acid SO_3 and soda $Na_2\ O$. But now the way of regarding this change has been modified. The sodium sulphate is supposed to split up into potassium, K, and the electro-negative group, $S\ O_4$; the metal, K, being liberated at the negative electrode, decomposes the water, and in effecting the solution of the salt, forming potash and liberating free hydrogen. Similarly, the electro-negative group, $S\ O_4$, which cannot of itself exist in a free state like $C O_2$, can, for instance, decompose into free oxygen gas (O) which is evolved, and into anhydrous sulphuric acid ($S O_3$), which immediately combines with water to form ordinary sulphuric acid, thus,

$$S O_3 + H_2 O = H_2 S O_4.$$

When we come to deal with still more complicated substances, the decomposition which ensue on their being subjected to the action of voltaic electricity are of a very involved nature. Berthelot, and some of the other French scientists of his school, have carried their researches into many an unexplored direction, and in connection with such research, the names of Kolbe, Kaempf, Brazier, Gossleth, Wurtz, Schoslemmer, and Kekulí, cannot avoid mention.

The latest work upon the electrolysis of complicated substances is reported from Russia, where, before one of the learned societies of St. Petersburg, N. Burp has read an important paper.

Burp considers that the reaction which takes place when fatty acids are subjected to electrolysis is a very complicated one, and cannot be represented by a simple chemical equation. He does not, however, support Kekulí's views. This scientist represented the decomposition of the fatty acids by the following general formulæ :—

$$C_n H_{2n} (C O O M)_2 = M_2 + 2 C O_2 + C_n H_{2n} \text{ and}$$

$$2 C_n H_{2n+1} (C O O M) = M_2 + 2 C O_2 + (C_n H_{2n+1})_2$$

But these equations do not represent facts according to Burp. He says the complicated groups are not decomposed into their negative constituents, but that they enter into reaction with water, reforming the original acid and oxygen, and that the latter, on being liberated, oxidises the electrolyte, and thus forms the different products.

The original paper contains a detailed description of Burp's apparatus, the preparation of the pure substances, and a large set of tabularly arranged analytical data of the gaseous products. It is shown also that the nature and relative quantity of the products obtained at the anode vary very considerably with varying concentrations, intensity of current, size and surface of the electrodes and especially with the temperature of the electrolyte.

The opinion on the complexity of the chemical process in the electrolysis of most substances was first pronounced by Bourgoni, and Burp says that his experiments entirely confirm this view.

UNDERGROUND AND OVERHEAD ELECTRIC WORK.

IN undertaking underground electrical work, it is essential to provide a good and lasting insulating covering for the buried wires, and also some means of protecting the cables from mechanical injury. This is not all that is required, for, so soon as the switch boxes and other connections are joined on as part of the circuit, an insulation of 500 megohms per mile in the cable *per se* will drop to three or four megohms resistance, or even less ; besides, after a time, from various causes, a cable may show a perceptible drop in insulation. This drop will often be permanent. In a cable insulated with India-rubber, contact with pitch or similar material has been known to lower the resistance of the rubber ; but this does not materially damage the cable for practical purposes, beyond the lowering of insulation, as in other respects it is perfectly sound. The big drops in insulation do not arise from this sort of mishap, but more frequently, as Mr. Degenhardt states in a paper read before the Chicago Electric Club, from bad jointing, moisture, and insufficiently insulated switch boxes ; and therefore, in selecting men to do the difficult work of making joints, it is well to secure those of high class character, and instil into their minds the fact that it is not how many joints they can make, but how well they can do them. There is little to complain of in the quality of the cables employed, as manufacturers supplying them make them to meet the varying requirements of their customers, and accompanied with a guarantee. The underground work in Chicago is a success, proving what can be accomplished by an honest effort to comply with the ordinance of the Common Council, ordering all electric conductors to be placed beneath the surface of the streets. The area ways under the side walks was a favourable circumstance connected with this underground construction, practically forming a ready made conduit. Not every city in the States has this advantage. The conduits in which the cables are placed are of various kinds. viz. : iron pipe laid in the earth without any protection ; iron pipe laid in concrete ; iron pipe, cement lined, laid in concrete and multitubular blocks of bituminous concrete about 4 feet long. Manholes at intervals, with watertight double covers. The iron pipe used for the conduit is thoroughly reamed at the ends to remove the burr. All pipes are also laid with a grade to draw off condensation water into the manholes. Quite an elaborate set of tools and accessories has been devised for manipulating the cables. Of course, this underground service is not perfect ; but we have it on the authority of Professor Barrett that it is safe, feasible, and practicable. With the exception, perhaps, of small cities with small service, overhead systems will soon be things of the past. The people wish to get rid of overhead high pressure wires, so do the electricians, but capitalists do not. The electric light people assemble together from time to time, and they tear the underground service all to pieces. None are so blind as the people who will not see ; for instance, some two years back the City of New York appointed a delegation to visit Chicago and examine the underground service in that city. The gentlemen forming the delegation called on Prof. Barrett at his office, and were offered every facility to view the system. They did not avail themselves of the opportunity, but promptly returned home. They sent in a report stating that they had not seen a list of underground work in Chicago, which was true. Next year, one of them again called on the chief of the Telegraph Department, who said to him : " Do you want to make a report on underground work this time ? " adding, on receiving an answer in the affirmative, " You are going to see the underground service this time." The delegate was then taken out and deposited in a manhole. If report may be believed, the above is not the only instance of jobbery perpetrated during the long-continued battle between the advocates of overhead and underground systems. It is charged against the upholders (shall we say the capitalists) of the overhead system that in order to bear out their assertion that underground electrical work for electric lighting was impracticable, they deliberately put down cables which they knew would not work, and by their failure produced spurious evidence against the rival system. It is not unreasonable to conjecture that the celebrated pole-chopping incident at New York was the outcome of some disclosure connected with this party spirit.

It is stated that the cost of running underground wires for arc lighting purposes, including cost of conduits, interest on investment, cleaning out manholes, repairs to and the maintenance of cables, and depreciation of the system, is nearly one cent. per hour over the cost of wires carrying the same current overhead. In the long run, this overcharge will amount to *nil ;* it is even questionable whether the difference in cost between the two methods is not already overstated, considering it appears to be an accepted fact that a larger proportion of the electric current reaches its destination through the underground mains than by the overhead line.

Telephony in Iceland.—A telephone line, about five miles long, has been established in Iceland. It is regarded as a great curiosity, being the first ever established on the island.

NOTES ON ECONOMY IN CONDUCTORS IN SYSTEMS OF DISTRIBUTION OF ELECTRICAL ENERGY.*

(Concluded from page 714.)

Variable but Uniform Current Circuits.

If the current in a circuit is not a constant quantity—as in the case of series arc lighting—but variable throughout each day, and from day to day throughout the year, the value previously obtained for the most economical current density to employ refers to the square root of the mean square of the current for the year. In estimating or planning a system of mains it is more convenient to think about the most economical current density referred to the maximum current; that is to say, it is better to know that the greatest economy will be obtained in a given circuit if the current density, when the maxim current is flowing in it, is, say 500 ampères per square inch, than to know that you obtain the most economical arrangement if the current density of the square root of the mean square of the current is, say, 300 ampères per square inch.

It is necessary, then, to consider what the ratio of the maximum current to the square root of the mean square of the current is likely to be in a given circuit; and the best way to arrive at this value is by examination of load diagrams obtained from similar districts.

When Prof. Forbes, in 1885, so strongly advocated the most thorough and careful working out of any system of mains to be laid down in order to obtain the most economical arrangement possible, electrical engineers were necessarily very much in the dark as to the data upon which to base their calculations. It is absolutely essential, in order to plan the most economical arrangement possible, to know beforehand what kind of load diagram you are likely to get. Fortunately, we have now a certain amount of experience to help us, but there is no doubt that in this respect the experience of the next 10 years will be most valuable.

I have worked out one or two load diagrams for a single day in order to give an example. For this diagram, which was taken at Boston, the ratio of the maximum current to the square root of the mean square works out to 2·34, and for this second diagram, which was sent out by a town in the West of England in order that maintenance estimates might be prepared, the ratio is 3·57, and for this third diagram the ratio will be between 2·5 and 3·0.

With a slide rule and planimeter it is, of course, a very easy matter to determine this ratio for any given load diagram. The value to be used, however, is that obtained from a complete set of diagrams taken at short intervals throughout the year, and in connection with this it may be mentioned that Dr. Gustav Rasch states that the value of this ratio (as obtained by observations at different central stations during one year, and taking the average value) is 3·41.

To take an example, let us suppose that the cost of a Board of Trade unit is 3d., that the sum of the rates of interest, depreciation, &c., is 15 per cent., that current flows throughout the year in the circuit under consideration, that the ratio of the maximum current to the square root of the mean square is 3·2, and that the cable is 19-stranded Silvertown L. We have thus

$$b = 3{\cdot}39$$
$$c = 3$$
$$d = 15$$
$$n = 8{,}760$$

hence $$\mathrm{D} = 3{\cdot}2 \times 7{,}513\sqrt{\frac{3{\cdot}39 \times 15}{8{,}760 \times 3}} = 1{,}058.$$

In this case, then, the most economical current density is 1,058 ampères to the square inch for the maximum current.

This determination of the most economical current density to employ for a given type of cable applies only to cases in which the current density is uniform throughout the cable under consideration. This is so, of course, in feeders, but not in the mains proper of a system of parallel distribution.

In the latter case the current flowing across any section of the conductor diminishes as the distance of the section under consideration increases from the feeding points. If we assume that in the mains between two pairs of feeding points the current taken off per yard is constant, we can determine a multiplier for the most economical current density, obtained on the assumption that the current is uniform between the feeding points, which will give us what is really the most economical (maximum, or at a section very near the feeding points) current density to employ in the mains

In the case we have supposed it is easy to see that this multiplier is $\sqrt{3}$ or 1·732. Now if we take, as before, 19-stranded Silvertown L cable, and make the same assumptions as to the cost of energy, &c., we find that the proper size of main to employ is that which gives us a current density of 1,832 ampères to the square inch at a section very close to the feeding points, and when the maximum current is flowing.

In the case of any other law according to which the current taken off per yard may vary, it is very easy by constructing, firstly, the curve of flow of current along the main, and secondly, the curve of the squares of the current, to deduce the proper multiplier by means of a planimeter and slide-rule.

The process of making the foregoing calculations for any particular case is certainly easy and very fairly rapid, but it is obvious that before attempting to design a set of mains for a particular district, a thorough canvass should be made to ascertain its special requirements.

It should be remarked that the preceding investigation as to the effect of non-uniformity of current in the mains assumes that the load diagrams for the different buildings supplied between two pairs of feeding points are similar in character, a case which in general does not occur in practice, but for which allowance must be made either in the selection of an average load diagram or subsequently by special calculation.

I may end this portion of these notes by observing that though the current density arrived at may seem sometimes rather great, it occurs for such a very limited time that it is not likely to be harmful to the cables used.

Transmission of Power to Stationary Motors.

The whole of the foregoing relates to general supply of energy from central stations, and the conclusions arrived at were all based upon the fact that in such work you have to maintain a definite pressure at the consumers, so that the current to be supplied is a fixed quantity.

As is very well known, Sir William Thomson first pointed out in 1881, that in such cases the current density to be employed is independent of the length of conductor through which the energy is to be transmitted, and that the proper gauge to employ for a definite current is that which makes the value of the annual waste of energy per mile equal to the interest, depreciation, &c., on the capital laid out in conductor per mile.

There are, however, a large number of cases to which the above does not apply at all, and the transmission of power from a source where it is cheap to a distant point where it is valuable, is one of the most important of these at present.

In a very important paper read by Profs. Ayrton and Perry before the Society of Telegraph Engineers and Electricians, the authors gave, among other things, the solution of the following problem: What is the most economical current density to employ when a certain power, P, has to be furnished at the end of $\frac{n}{2}$ miles, and when the pressure at the source has been fixed at V volts?

If C is the current in ampères, r the resistance of the conductor per mile in ohms, t a constant—depending on the number of hours of working per annum, the cost of the cable per pound of copper, the sum of the rates of interest, depreciation and maintenance, and the value of a Board of Trade unit—and, F (C, r), the total waste of energy per mile reckoned in watts (*i.e.*, with the interest, depreciation, &c., on the cable expressed in watts as well as the actual waste of energy in the cable), we have

$$\mathrm{F}(\mathrm{C}, r) = \mathrm{C}^2 r + \frac{t^2}{r} \qquad \text{(i.)}$$

and further, $$f(\mathrm{C}, r) = \mathrm{P} - \mathrm{C}(\mathrm{V} - n\,\mathrm{C}\,r) = 0 \qquad \text{(ii.)}$$

From these two equations we have to determine C and r, and hence the current density D, so that F (C, r) is a minimum.

As you know, the values of C and r, which make F (C, r) a minimum, are those obtained from the equations

$$\left(\frac{d\,\mathrm{F}}{d\,\mathrm{C}}\right) \cdot \left(\frac{d f}{d\,r}\right) - \left(\frac{d\,\mathrm{F}}{d\,r}\right) \cdot \left(\frac{d f}{d\,\mathrm{C}}\right) = 0 \qquad \text{(iii.)}$$

and $$f(\mathrm{C}, r) = \mathrm{P} - \mathrm{C}(\mathrm{V} - n\,\mathrm{C}\,r) = 0 \qquad \text{(ii.)}$$

From these we obtain

$$\mathrm{C} = \frac{\mathrm{P}}{\mathrm{V}} \frac{n\,t + \sqrt{(\mathrm{V}^2 + n^2 t^2)}}{\sqrt{(\mathrm{V}^2 + n^2 t^2)}} \qquad \text{(iv.)}$$

and $$\mathrm{D} = 23{\cdot}5 \frac{\mathrm{V}\,t}{1 + \sqrt{(\mathrm{V}^2 + n^2 t^2)}} \qquad \text{(v.)}$$

the constant 23·5 being the conductivity of a copper conductor one mile long of one square inch sectional area.

If we put $\frac{n\,t}{\mathrm{V}} = \tan\phi$,

$$\mathrm{C} = \frac{\mathrm{P}}{\mathrm{V}}(1 + \sin\phi) \qquad \text{(vi.)}$$

and $$\mathrm{D} = 23{\cdot}5\,\frac{\mathrm{V}}{n}\left(\frac{\sin\phi}{1 + \sin\phi}\right) \qquad \text{(vii.)}$$

I have calculated the following table of values of $(1 + \sin\phi)$ and $\left(\frac{\sin\phi}{1 + \sin\phi}\right)$ for values of $\tan\phi$ between 0·025 and 4·0, thus embracing all practical cases, I believe. (See Table A.)

From this table, or from the curves given which have been constructed from it, it is a very easy matter to determine the proper current density to employ in any given case without any further calculation than that readily performed with a slide-rule.

With regard to t, its value is obtained from the equation

$$t = 93{\cdot}6\sqrt{\frac{\mathrm{L}\ \mathrm{Q}}{\mathrm{N}\ \mathrm{U}}},$$

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* Paper read before the Old Student's Association, December 4th, by Hamilton Kilgour, member,

TABLE A.—TRANSMISSON OF POWER.

$\tan\phi$.	[1 + $\sin\phi$.	$\frac{\sin\phi}{1+\sin\phi}$.	$\tan\phi$.	1 + $\sin\phi$.	$\frac{\sin\phi}{1+\sin\phi}$.	$\tan\phi$.	1 + $\sin\phi$.	$\frac{\sin\phi}{1+\sin\phi}$.
0	1·0000	0·0000	0·6	1·5145	0·3397	1·8	1·8742	0·4664
0·025	1·0250	0·0244	0·7	1·5734	0·3644	1·9	1·8849	0·4695
0·05	1·0499	0·0471	0·8	1·6246	0·3845	2·0	1·8945	0·4721
0·075	1·0748	0·0696	0·9	1·6689	0·4008	2·2	1·9104	0·4765
0·1	1·0995	0·0905	1·0	1·7072	0·4143	2·4	1·9231	0·4800
0·15	1·1482	0·1291	1·1	1·7402	0·4254	2·6	1·9333	0·4828
0·2	1·1961	0·1640	1·2	1·7680	0·4344	2·8	1·9417	0·4850
0·25	1·2425	0·1952	1·3	1·7924	0·4421	3·0	1 9487	0·4868
0·3	1·2874	0·2232	1·4	1·8137	0·4486	3·3	1·9570	0·4888
0·35	1·3303	0 2483	1·5	1·8319	0·4541	3·6	1·9635	0·4907
0·4	1·3713	0·2708	1·6	1·8482	0·4589	4·0	1·9701	0·4924
0·5	1·4472	0·3090	1·7	1·8619	0·4629	∞	2·0000	0·5000

where

L = cost in pence in copper in cable per pound.
N = number of hours in working per annum.
Q = sum of the rates of interest, depreciation, and maintenance on capital laid out in cable,

and

U = cost in pence of a Board of Trade unit.

If L = cost in £ of copper in cable per ton, the equation becomes

$$t = 30{\cdot}6\sqrt{\frac{L\ Q}{N\ U}}.$$

I have thought it of interest to members that tables and curves showing the effects produced in a particular case of varying the different quantities, t, v, and n, should be given, and I have therefore taken the following cases:

(i.) $v = 2{,}000$ volts.
$n = 10$ miles.
t variable between 15 and 50.

(ii.) $n = 10$.
$t = 25$.
v variable between 500 volts and 10,000 volts.

(iii.) $v = 2{,}000$ volts.
$t = 25$.
n variable between ¼ mile and 50 miles.

And lastly,

(iv.) $v = 5{,}000$ volts.
$t = 25$.
n variable between one mile and 500 miles.

TRANSMISSION OF POWER.

(i.) $P = 87{,}700$ watts., $v = 2{,}000$ volts. $n = 10$ miles.

t.	C.	D.	P_1.	P_2.	P_3.	K.
15	47·13	351·4	6,559	7,619	14,178	7·0
20	48·21	467·9	8,726	10,655	19,382	9·0
25	49·29	582·7	10,878	13,958	24,836	11·0
30	50·35	696·8	13,009	17,542	30,551	12 9
35	51·41	809·8	15,118	21,415	36,533	14·7
40	52·45	921·3	17,199	25,591	42,790	16·4
50	54·48	1,139	21,270	34,892	56,162	19·5

(ii.) $n = 10$. $t = 25$.

V.	C.	D.	P_1.	P_2.	P_3.	K.
500	253·8	524·5	39,220	102,681	141,901	30·9
750	153·9	556·6	27,732	53,386	81,118	24·0
1,000	109·0	569·4	21,270	34,892	56,162	19·5
1,500	68·08	579·1	14,418	20,091	34,509	14·1
2,000	49·29	582·7	10,878	13,958	24,836	11·0
3,000	31·66	585·3	7,283	8,602	15,885	7·7
4,000	23·29	586·2	5,471	6,198	11,669	5·9
5,000	18·42	586·7	4,380	4,840	9,220	4·8
7,500	12·08	587·1	2,922	3,123	6,045	3·2
10,000	8·99	587·3	2,192	2,304	4,496	2·4

(iii.) $v = 2{,}000$. $t = 25$.

n.	C.	D.	P_1.	P_2.	P_3.	K.
·25	43·99	587·2	274	276	550	0·3
·5	44·12	587.2	548	555	1,103	0·6
1·0	44·40	587·1	1,096	1,124	2,220	1·2
2·0	44·95	587 0	2,192	2,304	4,496	2·4
4·0	46·04	586·5	4,380	4,840	9,220	4·8
6·0	47·13	585·6	6,559	7,619	14,178	7·0
8·0	48·21	584·3	8,726	10,655	19,381	9·0
10·0	49·29	582·7	10,878	13,958	24,836	11·0
15·0	51·93	577·1	16,162	23,465	39,627	15·6
20·0	54·48	569·7	21,270	34,892	56,162	19·5
25·0	56·93	560·5	26,158	48,397	74,555	23·0
30·0	59·25	549·9	30,794	70,306	101,100	26·0
35·0	61·43	538·0	35,152	82,181	117,333	28·6
40 0	63·46	525·3	39,220	102,680	141,900	30·9
45·0	65·35	511·9	42,996	125,700	168,700	32·8
50·0	67·09	498·0	46,481	151,310	197,790	34·6

(iv.) $v = 5{,}000$ $t = 25$.

n.	C.	D.	P_1.	P_2.	P_3.	K.
1	17·63	587·4	439	443	881	0·5
2	17·72	587·4	877	895	1,772	1·0
5	17·98	587·2	2,192	2,304	4,496	2·4
10	18·42	587·6	4,380	4,840	9,220	3·7
20	19·29	584·5	8,727	10,655	19,382	9·1
50	21·79	569·8	21,270	34,892	56,162	19·5
100	25·38	525·4	39,220	102,681	141,901	30·9
150	28·06	469·9	52,620	210,480	263,100	37·5
200	29·94	415·4	62,013	361,430	423,440	41·5
250	31·24	467·0	68,481	556,550	625,030.	43·9
300	32·13	325·8	72,970	795,990	868,960	45·4
350	32·77	291·4	76,140	1,079,700	1,155,800	46·5
400	33·23	262·7	78,440	1,407,600	1,486,000	47·2
450	33·57	238·6	80,140	1,779,500	1,859,700	47·8
500	33·83	218·2	81,426	2,195,500	2,276,900	48·2

In each case the power to be transmitted, P, has been taken as 87,700 watts, which, with motors of 85 per cent. efficiency, will give 100 brake H.P.

The curves (*see* pp. 500 and 501) and tables show what changes are produced in the different quantities tabulated—the most economical current density being employed in each case. I should mention that in the curves and tables are included P_1, P_2, P_3, and K where

P_1 = waste of energy in conductor.
P_2 = interest, depreciation, &c., on capital laid out in cable.
$P_3 = P_1 + P_2$.
K = percentage loss of volts in transmission of the power in each case.

You will notice that in cases of transmission of power over a considerable distance, P_1, the power wasted, bears a pretty high ratio to P, the power transmitted, so that the power of the generators must be considerably in excess of that actually required by the motors.

Now the value of U, and hence of t, depends to a certain extent upon the power of the generators ($P + P_1$), and it is not difficult to see that this relation can be expressed by the equation

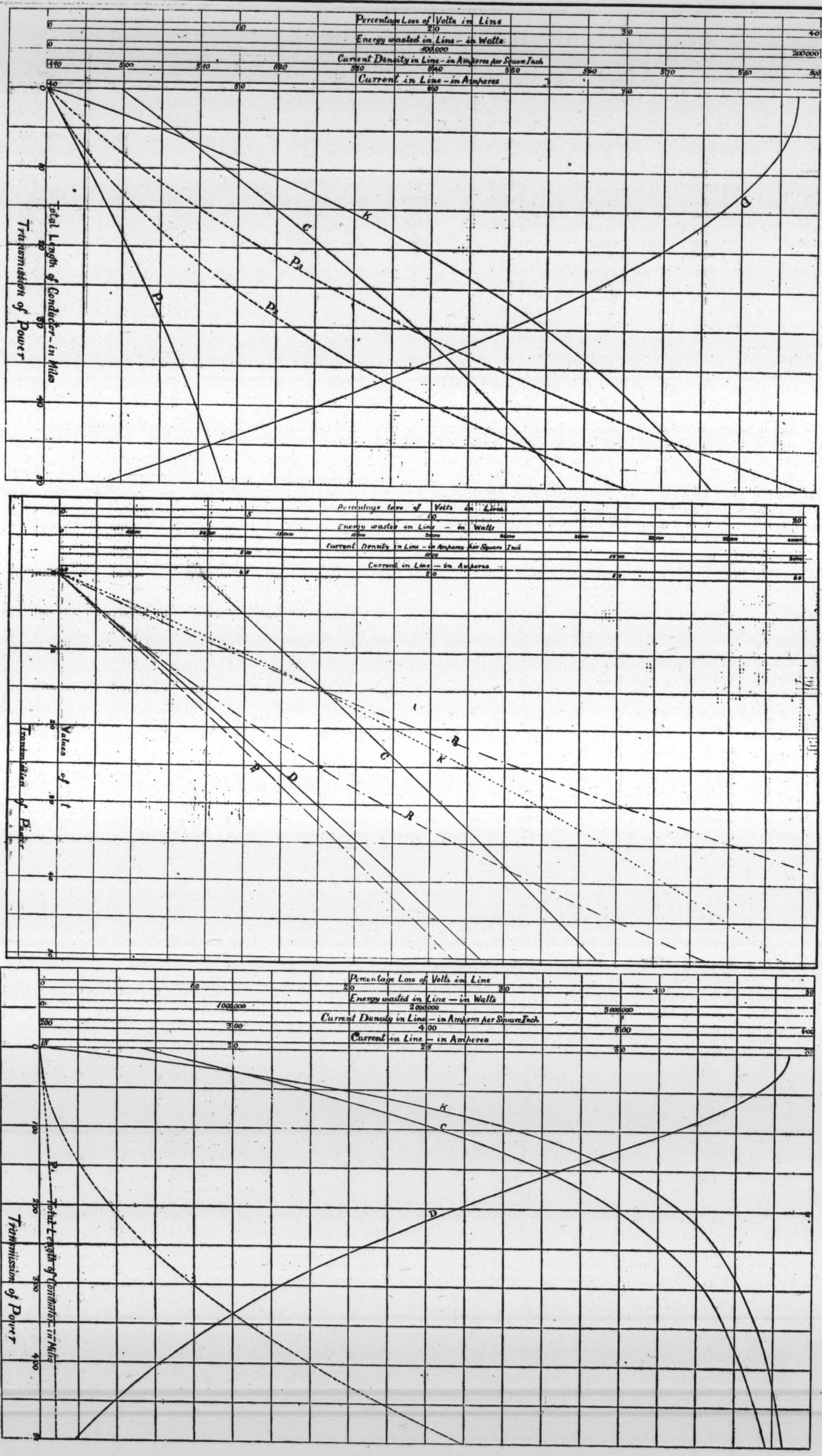
$$t = \sqrt{\frac{P + P_1}{A + B P_1}},$$

where A and B are constants depending on the conditions of the case under consideration.

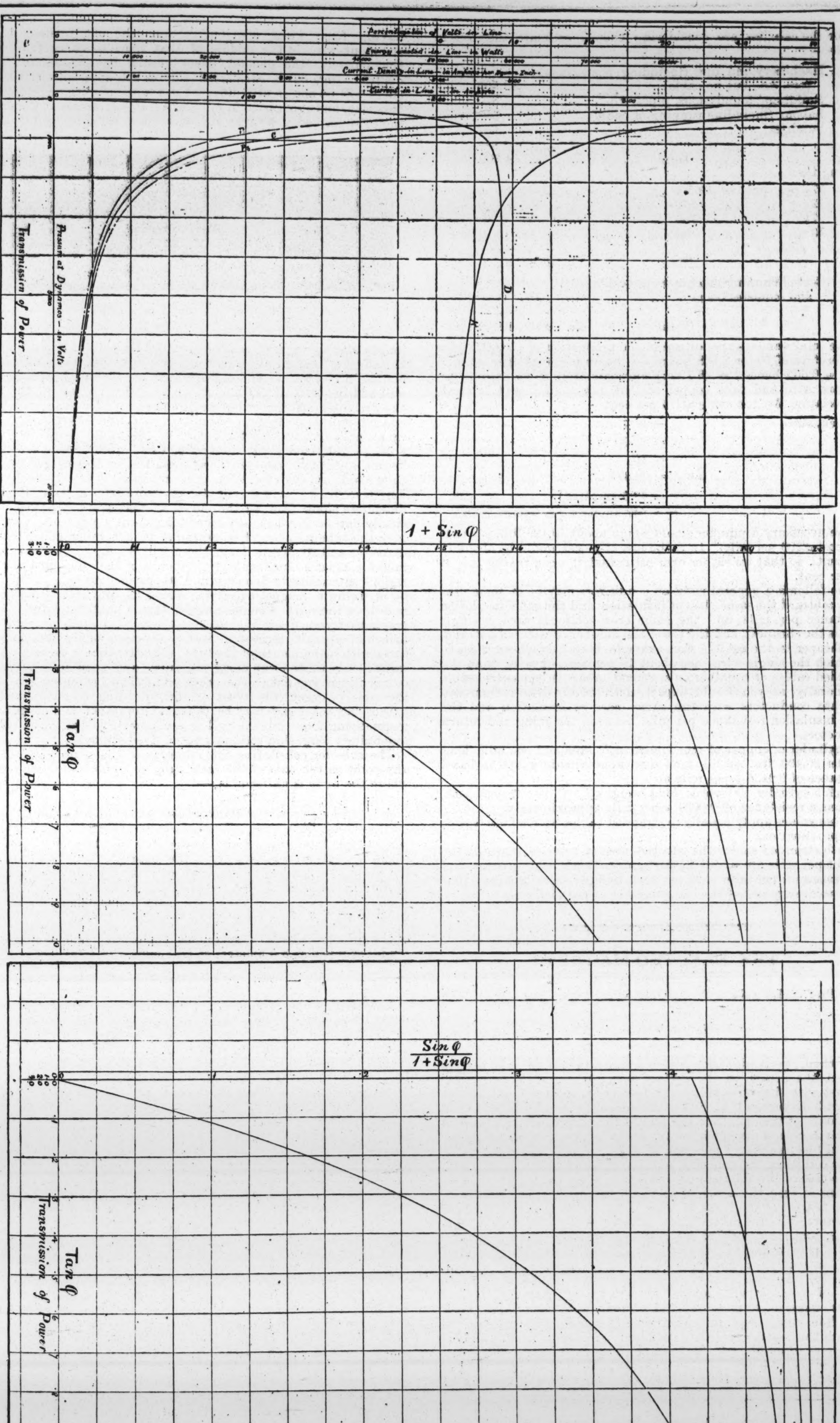
However, from these tables it is easy to judge approximately beforehand what P_1 will be in any given case, so that $P + P_1$ being known, t can be then accurately estimated, and C and D obtained as before. To take an example, let us suppose that we want to transmit 100 brake H.P. from a waterfall to a mill at a distance of five miles. We will suppose that there is an effective head of 37 feet, that the efficiency of the motors is 85 per cent., that the loss in the line is about 15 per cent., that the generators have an efficiency of 87 per cent., that there is a loss of 5 per cent. in belting, and that we take 2,000 volts as our working pressure.

The power to be transmitted to motors will be 87,700 watts, that developed by the generators 110,000 watts, and that given out by turbines 164 brake H.P.

For the water engines I shall suppose that we use 15-inch Victor turbines, of which the cost, and also that of the accessories, &c., has been kindly furnished me by Mr. Nell, and for the dynamos (motors and generators) I shall take the costs of Victoria machines in this example.



CURVES ACCOMPANYING MR. KILGOUR'S PAPER.



CURVES ACCOMPANYING MR. KILGOUR'S PAPER.

For the case we are considering, then, I estimate the costs as under:—

Machinery and line (including posts, insulators, &c., but no cable)	£2,500
Buildings' foundations, pipes, &c.	870
Labour (including running of cable)	750
Sundries	180
Total	£4,300

Taking then

17½ per cent. cn £2,500	£437	10	0
12½ „ „ 870	108	15	0
7½ „ „ 750	56	5	0
10 „ „ 180	18	0	0
Total	£620	10	0
Cost of running machinery at both ends, and sundries (say)	150	0	0
Total	£770	10	0

The total annual expenditure in the production of 110,000 watts is therefore £770 for 2,808 hours (54 hours per week) per annum, or $\text{U} = 0{\cdot}6\text{d}$; hence $t = 26{\cdot}7$ very approximately if we assume use of bare wire and take copper at 9½d. per pound, and interest, depreciation, &c., on cable at 15 per cent.

Then, since $t = 26{\cdot}7$

$\text{V} = 2{,}000$

$n = 10,$

$\tan \phi = 0{\cdot}1335$

and $\text{C} = 49{\cdot}6$ ampères

$\text{D} = 547$ ampères per square inch.

The necessary conductor would weigh about 10,120 lbs., per mile and cost £390 per mile. In it the loss of power would be about 12 per cent., so that we rather over-estimated it when taking this at 15 per cent.

The following general notes on conductors may be of some use:

Of cables of the same class of insulation, and the same insulation resistance per mile, and the same cross-sectional area, a single wire is the cheapest, and the fewer the number of wires in a strand, the cheaper is the cable. For example, take Silvertown class S, in which the single wires are about 18 per cent. cheaper than the stranded cables of equal cross-sectional area. A concentric cable is generally, as you would expect, considerably dearer than two separate conductors with the same class of insulation and the same insulation resistance per mile between the going and return conductor.

A cylinder of copper of one square inch area and one mile long weighs 20,400 lbs., or 9·1 tons very approximately, and it has a resistance of 0·0425 ω per mile at 60° F.

Such a cylinder 100 yards long weighs 1,160 lbs., or 0·52 tons, and has a resistance of 0·0024 ω per mile approximately.

These values apply equally to stranded cables with a high degree of approximation.

With stranded cables the effective area of cross-section and the weight per mile are about 2½ per cent. to 3 per cent. greater, and the resistance per mile is 2½ per cent. to 3 per cent. less than that of a cable composed of the same number of parallel wires.

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page 682.*)

If, then, we could take a *very* long magnet, we may utterly neglect the action on the distant pole. If I had a long steel magnet with the south pole 5 or 6 feet away, and the north pole at a point 3 diameters (*i.e.*, 6 centimetres in this case) distant from the mouth of the coil, then the pull of the current in one spiral on the north pole, 3 diameters away, would be practically negligible; it would be less than 2 per cent. of what the pull would be of that single coil when the pole was pushed right up into it. But now, in the case of the tubular coil, consisting of at least a whole layer of turns of wire, the action of all of the turns has to be considered. If the nearest of the turns of wire is at a distance equal to three diameters, all the other turns of wire will be at greater distances, and, therefore, if we may neglect such small quantities as 2 per cent. of the whole amount, we may neglect their action also, for it will be still smaller in amount. Now, for the purpose of arriving at the action of a whole tube of coil, I will adopt a method of plotting devised by Mr. Sayers. Suppose we had a whole tube coiled with copper wire from end to end, its action would be practically the same as though the copper wire were gathered together in small numbers at distant intervals. If, for example, I count the number of turns in a centimetre length of the actual tubular coil which I used in my first experiment, I find there are four. Now if, instead of having four wires distributed over the centimetre, I had one stout wire in the middle of that space to carry four times the current, the general effect would be the same. This diagram (fig. 60) is calculated out on the supposition that the effect will be not greatly different if the wires were aggregated in that way, and it is easier to calculate. If, beginning at the end of the tube marked A, we take the wires over the first centimetre of length and aggregate them, we can draw a curve, marked 1, for the effect of that lot of wires. For the next lot, we could draw a similar curve, but instead of drawing it on the horizontal line we will add the several heights of the second curve on to those of the first, and that gives the curve marked 2; for the third part, add the ordinates of another similar curve, and so gradually build up a final curve for the total action of this tubular coil on a unit pole at different points along the axis. This resultant curve begins about 2½ diameters away from the end, rises gently, and then suddenly, and then turns over and becomes nearly flat with a long level back. It does not rise any more after a point about 2½ diameters along from A; the curve at that point becomes practically flat, or does not vary more than about 1 per cent., however long the tube may be. For example, in a tubular coil 1 inch in diameter and 20 inches long, there will be a uniform magnetic field for about 15 inches along the middle of the coil. In a tubular coil 3 centimetres in diameter and 40 centimetres long, there will be a uniform magnetic field for about 32 centimetres along the middle of the coil. The meaning of this is that the value of the magnetic forces down the axis of that coil begins outside the mouth of the tube, increases, rises to a certain maximim amount a little within the mouth of the tube, and after that is perfectly constant nearly all the way along the tube, and then falls off symmetrically as you get to the other end. The ordinates drawn to the curve represent the forces at corresponding points along the axis of the tube, and may be taken to represent not simply the magnetising force, but the pull on a magnetic pole at the end of an indefinitely long, thin steel magnet of fixed strength.

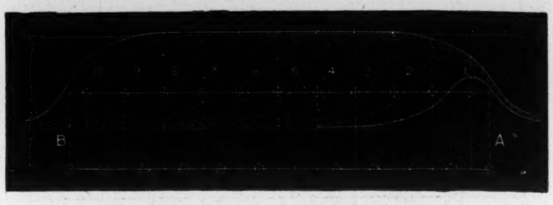


FIG. 60.—ACTION OF TUBULAR COIL.

The rule for calculating the intensity of the magnetic force at any point on the axis of the long tubular coil within this region where the force is uniform, is:—

$$H = \frac{4}{10} \pi \times \text{the ampere-turns per cm. of length.}$$

And, as the total magnetising power of a tubular coil is proportional not only to the intensity of the magnetic force at any point, but also to the length, the integral magnetising effect on a piece of iron that is inserted into the coil may be taken as practically equal to $\frac{4}{10} \pi \times$ the total number of ampere-turns in that portion of the tubular coil which surrounds the iron. If the iron protrudes as much as 3 diameters at both ends, the total magnetising force is simply $\frac{4}{10} \pi \times$ the whole number of ampere-turns.

Now that case is, of course, not the one we are usually dealing with. We cannot procure steel magnets with unalterable poles of fixed strength. Even the hardest steel magnet, magnetised so as to give us a permanent pole near, or at the end of it—quite close up to the end of it when you put it into a magnetising coil—becomes by that fact further magnetised. Its pole becomes strengthened as it is drawn in, so that the case of an unalterable pole is not one which can actually be realised. One does not usually work with steel: one works with soft iron plungers, which are not magnetised at all when at a distance away, but become magnetised in the act of being placed at the mouth of the coil, and which become more highly magnetised the further they go in. They tend, indeed, to settle down, with the ends protruding equally, for that is the position where they most nearly complete the magnetic circuit; where, therefore, they are most completely and highly magnetised. Accordingly, we have this fact to deal with, that whatever may be the magnetising forces all along a tube, the magnetism of the entering core will increase as it goes on. We must therefore have recourse to the following procedure. We will construct a curve in which we will plot, not simply the magnetising forces of the spiral at different points, but the product of the magnetising forces into the magnetism of the core which itself increases as the core moves in. The curve with a flat top to it corresponds to an ideal case of a single pole of constant strength. We wish to pass from this to a curve which shall represent a real case, with an iron core. Let us still suppose that we are using a very long core, one so long, that when the front pole has entered the coil, the other end is still a long way off. With an iron core, of course, it depends on the size and quality of the iron as to how much magnetism you get for a given amount of magnetising power. When the core has entered up to a certain point, you have all the magnetising forces up to that point acting on it: it acquires a certain amount of magnetism, so that the pull will necessarily go on increasing and increasing, although the intensity of the magnetic force from point to point along the axis of the coil remains the same, until within about two diameters from the far end. Although the magnetic force inside the long spiral remains the same, because the magnetism of the core is increasing, the pull goes on increasing and increasing (if the iron does not get saturated) at an almost uniform rate all the way up, until the piece of iron has been poked pretty nearly through to the distant end. In fig. 61, a tubular coil, B A, is represented. Suppose a long iron core is placed on the axis to the right, and that its end is gradually brought up toward B. When it arrives at X, the pull becomes sensible, and increases at first rapidly, as the core enters the mouth of the tube, then gently, as the core travels along, attaining a maximum, C, about at the further end, A, of the tube. When it approaches to the other end, A, it comes to the region where the magnetising force falls off, but the magnetism is still going on increasing, because something is still being added to the total magnetising power, and these two effects nearly balance one another, so that the pull arrives at the maximum. This is the highest point, C, on the curve; the greatest pull occurring just as the end of the iron core arrives at the bottom or far end of the tubular coil: from which point there is a very rapid falling off. The question of rapidity of descent from that point depends only on how long the core is. If the core is a very long one, so that its other pole is still very far away, you have a long, slow descent going on over some three diameters, and gradually vanishing. If, however, the other pole is coming up within measurable distance of B, then the curve will come down more rapidly to a definite point, X_1. To take a simple case where the iron core is twice as long as the coil, its curve will descend in pretty nearly a straight line down to a point such that the ends of the iron rod stand out equally from the ends of the tube.

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* Cantor Lecture. Delivered before the Society of Arts, February 3rd, 1890.

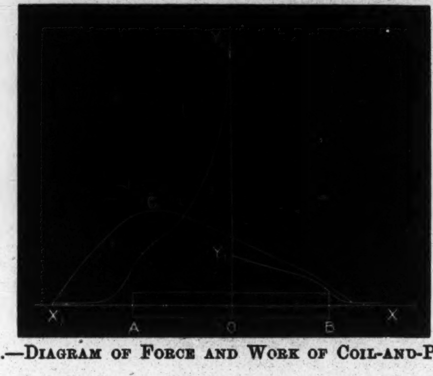

FIG. 61.—DIAGRAM OF FORCE AND WORK OF COIL-AND-PLUNGER.

Precisely similar effects will occur in all other cases where the plunger is considerably longer than (at least twice as long as) the coil surrounding it. If you take a different case, however, you will get another effect. Take the case of a plunger of the same length as the coil, then this is what necessarily happens. At first the effects are much the same; but as soon as the core has entered about half, or a little more than half its length, you begin to have the action of the other pole that is left protruding outside tending to pull the plunger back; and although the magnetising force goes on increasing the further the plunger enters, the repulsion exerted by the coil on the other pole of the plunger keeps increasing still faster as this end nears the mouth of the coil. In that case the maximum will occur at a point a little further than half way along the coil, and from that point the curve will descend and go to zero at A; that is to say, there will be no pull when both ends of the plunger coincide with the two ends of the coil. If you take a plunger that is a little shorter than the coil, then you find that the attraction comes down to zero at an earlier period still. The maximum pull occurs earlier, and so does the reduction of the pull to zero; there being no action at all upon the short core when it lies wholly within that region of the tube within which the intensity of the magnetic force is uniform. That is to say, for any portion of this tube corresponding to the flat top of the curve of Fig 60, if the plunger of iron is so short as to lie wholly within that region, then there is no action upon it; it is not pulled either way. Now these things can be not only predicted by the help of such a law as that, but verified by experiment. Here is a set of tubular coils which we use at the Finsbury Technical College for the purpose of verifying these laws. There is one here about nine inches long, one about half that length, another just a quarter. They are all made alike in this way, that they have exactly the same weight of copper wire, cut from the same hank, upon them. There are, of course, more turns on the long one than on the shorter, because with the shorter ones each turn requres on the average a larger amount of wire, and therefore the same weight of wire will not make the same number of windings. We use that very simple apparatus, a Salter's balance, to measure the pull exerted down to different distances on cores of various lengths. You find in every case the pull increases and becomes a maximum, then diminishes. We will now make the experiment, taking first a long plunger, roughly about twice as long as the coil. The pull increases as the plunger goes down, and the maximum pull occurs just when the lower end gets to the bottom; beyond that the pull is less. Using the same plunger, with these shorter coils, one finds the same thing, in fact more marked, for we have now a core which is more than twice the length of the coil. So we find, taking in all these cases, that the maximum pull occurs, not when the plunger is half way in, as the books say, but when the bottom end of it is just beginning to come out through the bottom of the coil that we are using. If, however, we take a shorter plunger, the result is different. Here is one just the same length as the coil. With this one the maximum pull does occur when the core is about half way in; the maximum pull is just about at the middle. Again, with a very short core—here is one about one-sixth of the length of the coil—the maximum pull occurs as it is going into the mouth of the coil; and, when both ends have gone in so far that it gets into the region of equable magnetic field there is no more pull on one end than on the other; one end is trying to move with a certain force down the tube, and the other end is trying to move with exactly equal force up the tube, and the two balance one another. If we carry that to a still more extreme case, and employ a little round ball of iron to explore down the tube, you will find this curious result, that the only place where any pull occurs on the ball is just as it is going in at the mouth. For about half an inch in the neck of the coil there is a pull; but there is no pull down the interior of the tube at all, and there is no measurable pull outside.

Now these actions of the coil on the core are capable of being viewed from another standpoint. Every engineer knows that the work done by a force has to be measured by multiplying together the force and the distance through which its point of application moves forward. Here we have a varying force acting over a certain range. We ought, therefore, to take the amount of the force at each point, and multiply that by the adjacent little bit of range, averaging the force over that range, and then take the next value of force with the next little bit of range, and so consider in small portions the work done along the whole length of travel. If we call the length of travel x, the element of length must be called d, x. Multiply that by f, the force. The force multiplied by the element of length, gives us the work d, w, done in that short range. Now the whole work over the whole travel is made up of the sum of such elements all added together; that is to say, we have to take all the various values of f, multiply each by its own short range d, x, and the sum of all those, writing $\int$ for the sum, would be equal to the sum of all the work; that is to say, the whole work done in putting the thing together will be written:

$$w = \int f\, d\, x.$$

Now, what I want you to think about is this: Here, say, is a coil, and there is a distant core. Though there is a current in the coil it is so far away from the core that practically there is no action; bring them nearer and nearer together; presently they begin to act on one another, there is a pull, which increases as the core enters, then comes to a maximum, then dies away as the end of core begins to protrude at the other side. There is no further pull at all when the two ends stand out equally. Now there has been a certain total amount of work done by this apparatus. Every engineer knows that if we can ascertain the force at every point along the line of travel the work done in that travel is readily expressed by the area of the force curve. Think of the curve, X, C, X, in fig. 61, the ordinates of which represent the forces. The whole area underneath this curve represents the work done by the system, and therefore represents equally the work you would have to do upon it in pulling the system apart. The area under the curve represents the total work done in attracting in the iron plunger, with a pull distributed over the range X, X_1.

Now I want you to compare that with the case of an electromagnet where, instead of having this distributed pull, you have a much stronger pull over a much shorter range. I have endeavoured to contrast the two in the other curves drawn in fig. 61. Suppose we have our coil, and suppose the core, instead of being made of one rod such as this, were made in two parts, so that they could be put together with a screw in the middle, or fastened together in any other mechanical way. Now first treat this rod as a single plunger, screw the two parts together, and begin with the operation of allowing it to enter into the coil, the work done will be the area under the curve which we have already considered. Let us divide the iron core into two. First of all put in one end of it; it will be attracted up in a precisely similar fashion, only being a shorter bar, the maximum would be a little displaced. Let it be drawn in up to half way only; we have now a tube half filled with iron, and in doing so we shall have had a certain amount of work done by the apparatus. As the piece of iron is shorter, the force-curve, which ascends from X to Y_1, will lie little lower than the curve, X, C, X_1; but the area under that lower curve, which stops half way, will be the work done by the attraction of this half core. Now go to the other end and put in the other half of the iron. You now have not only the attraction of the tube, but that of the piece which is already in place, acting like an electro-magnet. Beginning with a gentle attraction, it soon runs up, and draws the force-curve to a tremendously steep peak, becoming a very great force when the distance asunder is very small. We have therefore in this case a totally different curve made up of two parts, a part for the putting in of the first half of the core, and a steeper part for the second; but the net result is, we have the same quantity of iron magnetised in exactly the same manner by the same quantity of electric current running round the same amount of copper wire—that is to say, the total amount of work done in these two cases is necessarily equal. Whether you allow the entire plunger to come in by a gentle pull over a long range, or whether you put the core in in two pieces—one part with a gentle pull, and the other with a sudden spring up at the end—the total work must be the same; that is to say, the total area under our two new curves must be the same as the area under the old curve. The advantage, then, of this coil-and-plunger method of employing iron and copper is, not that it gets any more work out of the same expenditure of energy, but that it distributes the pull over a considerable range. It does not, however, equalise it altogether over the range of travel.

A number of experimental researches have been made from time to elucidate the working of the coil and plunger. Hankel, in 1850, examined the relation between the pull in a given portion of the plunger and the exciting power. He found that, so long as the iron core was so thick and the exciting power so small that magnetisation of the iron never approached saturation, the pull was proportional to the square of the current, and was also proportional to the square of the number of turns of wire. Putting these two facts together we get the rule—which is true only for an unsaturated core in a given position—that the pull is proportional to the square of the ampère turns. This might have been expected, for the magnetism of the iron core will, under the assumptions made above, be proportional to the ampère turns, and the intensity of the magnetic field in which it is placed being also proportional to the ampère turns, the pull, which is the product of the magnetism and of the intensity of the field, ought to be proportional to the square of the ampère turns.

Dub, who examined cores of different thicknesses, found the attraction to vary as the square root of the diameter of the core. His own experiments show that this is inexact, and that the force is quite as nearly proportional to the diameter as to its square root. There is again reason for this. The magnetic circuit consists largely of air-paths by which the magnetic lines flow from one end to the other. As the main part of the magnetic reluctance of the circuit is that of the air, anything which reduces the air reluctance increases the magnetisation, and, consequently, the pull. Now, in this case, the relutctance of the air-paths is mainly governed by the surface exposed by the end portions of the iron core. Increasing these diminishes the reluctance, and increases the magnetisation by a corresponding amount. Von Waltenhofen, in 1870, compared the attraction exerted by two equal (short) tubular coils on two iron cores, one of which was a solid cylindrical rod, and the other a tube of equal length and weight, and found the tube to be more powerfully attracted. Doubtless, the effect of the increased surface in diminishing the reluctance of the magnetic circuit explains the cause of the observation.

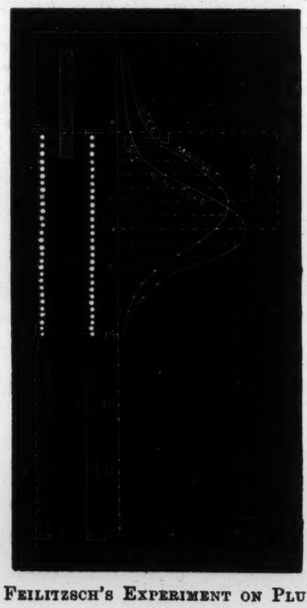

FIG. 62.—VON FEILITZSCH'S EXPERIMENT ON PLUNGERS OF IRON AND STEEL

Von Feilitzsch compared the action of a tubular coil upon a plunger of soft iron with that exerted by the same coil upon a core of hard magnetised steel of equal dimensions. The plungers, fig. 62, were each 10·1 centimetres long; the coil being 29·5 centimetres in length, and 4·2 in diameter. The steel magnet showed a maximum attraction when it had plunged to a depth of 5 centimetres, whilst the iron core had its maximum at a depth of 7 centimetres, doubtless because its own magnetisation went on increasing more than did that of the steel core. As the uniform field region began at a depth of about 8 centimetres, and the cores were 10·1 centimetres in length, one would expect the attracting force to come to zero when the cores had plunged into a depth of about 18 centimetres. As a matter of fact, the zero point was reached a little earlier. It will be noticed that the pull at the maximum was a little greater in the case of the iron plunger.

The most careful researches of late years are those made by Dr. Theodore Bruger, in 1886. One of his researches, in which a cylindrical iron plunger was used, is represented by two of the curves in fig. 63. He used two coils, one 3½ centimetres long, the other 7 centimetres long. These are indicated in the bottom left-hand corner. The exciting current was a little over 8 ampères. The cylindrical plunger was 39 centimetres long. The plunger is supposed, in the diagram, to enter on the left, and the number of grammes of pull is plotted out opposite the position of the entering end of the plunger. As the two curves show by their steep peaks the maximum pull occurs just when the end of the plunger begins to emerge through the coil: and the pull comes down to zero when the ends of the core protrude equally. In this figure the dotted curves relate to the use of the longer of the two coils. The height of the peak, with the coil of double length, is nearly four times as great, there being double ampère-turns of excitation. In some other experiments, which are plotted in fig. 64, the same core was used with a tubular coil 13 centimetres long. Using currents of various strengths, 1·5 ampère, 3, 4·8, 6, or 8 ampères,

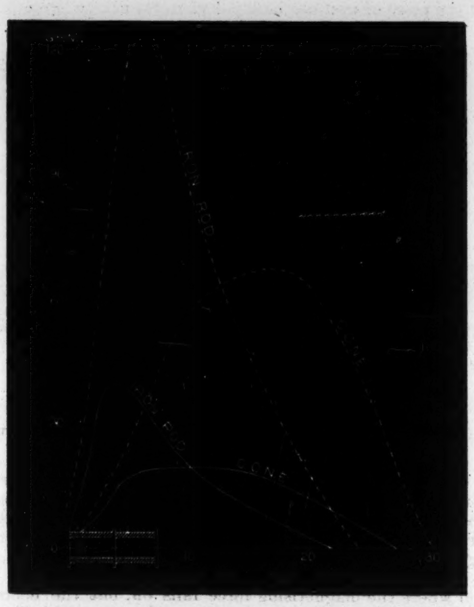

FIG. 63.—BRUGER'S EXPERIMENTS ON COILS AND PLUNGERS.

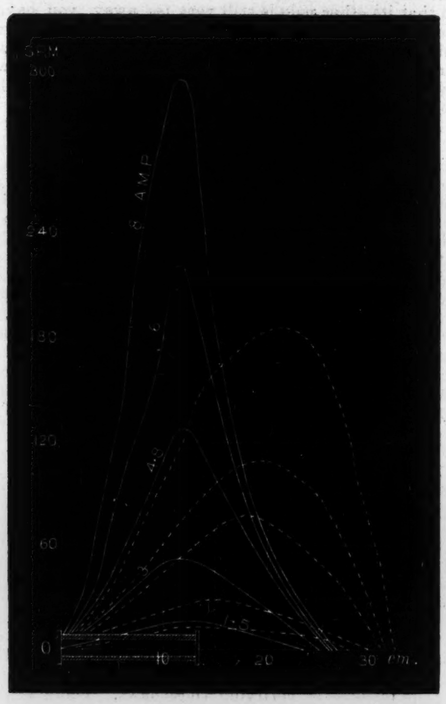

FIG. 64.—BRUGER'S EXPERIMENTS, USING CURRENTS OF VARIOUS STRENGTH.

the pull is of course different, but, broadly, you get the same effect, that the maximum pull occurs just where the pole begins to come out at the far end of the tubular coil. There are slight differences; with the smallest amount of current the maximum is exactly over the end of the tube, but with currents rather larger, the maximum point comes a little farther back. When the core gets well saturated, the force curve does not go on rising so far; it begins to turn over at an earlier stage, and the maximum place is necessarily displaced a little way back from the end of the tube. That was also observed by Von Waltenhofen when using the steel magnet.

(To be continued.)

LONDON COUNTY COUNCIL.

THE weekly meeting was held on Tuesday at Spring Gardens, S.W., Sir John Lubbock in the chair. The Highways Committee reported the following:

The council on the 30th of September last sanctioned the continued employment for three months in the engineer's department of a person, at a salary of £3 3s. a week, who has been since 25th February last assisting with the work connected with the business of which your committee has charge. The time referred to has now elapsed; but the chief engineer has informed us that the assistance it still required. We propose to report again on this matter after the Christmas vacation; and in the meantime we recommend: That the services of the temporary assistant now employed at a salary of £3 3s. a week in the engineer's department, be retained until the second meeting of the council in January next.

We have considered a letter from the London Electric Supply Corporation, asking that in the case of the service lines from distributing mains the one month's notice specified in the company's order may ~~not~~ be insisted upon, and that a shorter notice may be accepted. The company states that the Postmaster-General has agreed to accept a 48 hours' notice, and asks that the council will do the same. We are of opinion that, although in the case of the laying of service lines, the one month's notice is not necessary, the 48 hours' notice proposed by the company is on the other hand insufficient, and that at least four days' notice should be given by the company. We therefore recommend:—

That the London Electric Supply Corporation be informed with reference to the laying of service lines from distributing mains already laid, that the council will, until it gives notice to the contrary, accept four days' notice, instead of the one month's notice, required by the company's order.

We have considered a notice (Registered No. 139), dated 5th December, 1890, from the vestry of St. Pancras, of electric lighting works proposed to be carried out by the vestry in certain streets in the parish, under the provisions of the St. Pancras (Middlesex) Electric Lighting Order, 1883, as shown upon three plans and six drawings submitted with the application. The details shown are generally satisfactory, but if any high tension mains are to be used, some precautions appear to be necessary for the prevention of accidents. We recommend—

That the council do approve the works referred to in the notice (Registered No. 139), of the vestry of St. Pancras, dated 5th December, 1890, under the provisions of the St. Pancras (Middlesex) Electric Lighting Order, 1883; and that it be suggested to the vestry that where any high tension mains are used the frames and the cover of the boxes through which the mains pass should be carefully earthed.

The Kensington and Knightsbridge Electric Lighting Company has given a notice (Registered No. 140), dated 27th November, 1890, of a proposed extension of mains in Alfred Place West (1 plan). The works are of the usual description; and we recommend—

That the consent of the council be given to the works referred to in the notice (Registered No. 140) of the Kensington and Knightsbridge Electric Lighting Company, Dated 27th November, 1890.

A notice, dated 2nd December, 1890 (Registered No. 141), has been given by the Metropolitan Electric Lighting Company of intention to lay mains in Northumberland Avenue, from the Hotel Victoria to Whitehall, and thence along Whitehall and Whitehall Place to the company's station in Whitehall Court (1 plan). These works are of the same description as those of this company already sanctioned; and although there is a subway in Northumland Avenue, we think it unnecessary that the company should be required to lay in the subway the very short length of main for that thoroughfare included in the notice. We recommend:—

That the sanction of the council be given to the works referred to in the notice (Registered No. 141), dated 2nd December, 1890, of the Metropolitan Electric Supply Company, upon condition that the company do give two days' notice to the council's chief engineer before commencing the works; that the mains be enclosed in 5-inch iron pipe and be laid under the footways wherever it is found practicable to do so; that the covers of the boxes to be used shall consist of iron frames filled in with material to suit the paving; and that the works generally shall be of the character approved by the council on 1st October, 1889.

The London Electric Supply Corporation has served three notices (Registered Nos. 142, 143 and 144), one dated 25th November, and two 2nd December, 1890, under section 19 of the company's order of 1889, of works executed on emergency, in laying service lines to No. 15, Clifford Street, Bond Street, and to Nos. 14 and 42, Curzon Street. There is no reason for objecting to these works; and we report for the information of the council the receipt of the notices with regard to them.

ELECTRIC LIGHTING PROGRESS IN LONDON.*

By F. BAILEY, Assoc. M. Inst. C.E.

THE last paper on electric lighting read before the Society was by Mr. R. E. B. Crompton, in 1888, when he placed before you some of the difficulties and obstacles which were retarding the progress of electric lighting. The rapid progress made within the last 18 months will, however, show that these difficulties have, to a great extent, been removed by a number of supply companies having obtained Parliamentary powers to lay mains within certain specified areas into which London has been divided. I propose, therefore, to place before you, in general terms, the work done and in progress by the various companies, as the time at my disposal will not permit me to give minute details of generating stations and systems.

Through the kindness of Mr. J. W. Swan, I have the honour to show you the first lamp he made. It is to be hoped that this lamp will eventually come under the care of one of our great museums, in order that future ages may recognise the genius of Mr. Swan.

I have also to thank Mr. Sydney Morse for the loan of another valuable historical lamp, this being the first lamp constructed by Edison.

Turning to the record of general distribution of the electric light in London, you all know that practically nothing was done under the Act of 1882, but private enterprise provided fields for encouraging the efforts of the electrical engineer, and foremost amongst these must be mentioned the Grosvenor Gallery station, which did such good service in making the capabilities of the light known, and in proving the absolute necessity that existed for it; for however defective the supply may have been towards the close of the existence of the station (owing to the plant being overloaded), we owe a debt of gratitude to Lord Crawford for his energetic support to this enterprise, and to those who worked so hard to bring it to perfection. Mr. Ferranti, and those who worked with him at the Grosvenor, laid the foundation stone of a satisfactory transformer system, and as they had no Parliamentary powers to lay down underground mains, overhead lines were run in all directions. The perfection to which they brought the details of overhead construction is so fully proved by the absence of accidents, that it is much to be regretted that the overhead conductors in the United States were allowed to have been put up with no regard to common sense or safety.

It is frequently stated that the Electric Lighting Act of 1882 did much towards stifling inordinate speculation, but in attempting to make people wise by this Act of Parliament, a very serious check was placed upon the development of electrical progress.

The enormous strides which have been made under the more encouraging Electric Lighting Act of 1888 will convince everyone that it was urgently required, and electrical engineers fully realise what they owe to Sir Frederick Bramwell for his share in framing this Act. One of the consequences of this Act was a deluge of applications for provisional orders. A court of enquiry was therefore ordered by the Board of Trade, who appointed Major Marindin as their inspector for this purpose.

If you carefully read the 18 days' evidence given, you will probably be convinced that every system was the best. The inquiry lasted several days, and resulted in the granting of provisional orders, confirmed by Parliament in August, 1889, to the companies mentioned in the summary on page 54, which also includes other information.

I must here gratefully acknowledge the very cordial assistance which the engineers of the various companies have given me.

We will now very briefly go round the stations of the companies, commencing with

The Kensington and Knightsbridge Electric Light Company.

This company commenced work under the name of the Kensington Court Electric Light Company in the autumn of 1886, and under Mr. Crompton's able guidance made such rapid progress that they commenced to supply current in January, 1887, using underground mains and running their plant in a temporary building. The Board of Trade license under which the work commenced, is incorporated in the company's provisional order of 1889, which authorises them to supply a portion of the parish of Kensington, St. Mary Abbot, and the detached portion of the parish of St. Margaret, Westminster.

The direct current is employed in conjunction with "Howell" secondary batteries, the pressure being 200 volts on the 3-wire system, with 100 volts in the houses.

The satisfactory use of secondary batteries in this manner has attained its present development mainly through the indefatigable labours of Mr. J. C. Howell.

Two generating stations are erected, one at Kensington Court, and the other at Chapel Place, Knightsbridge, the plant consisting of "Babcock and Wilcox" boilers and exhaust steam feed water heaters, "Willans's" compound engines combined direct with Crompton dynamos and "Howell" batteries in both stations. There is also a battery station situated near the centre of the Kensington district at Queen's Terrace Mews, where two large "Howell" batteries are placed. In all cases ample space is provided for the future extension of the plant when required. Arrangements are provided on the Kensington Court station switchboards to enable any dynamo to be used for charging the distant battery station, to which a pair of charging mains are laid, Mr. Crompton also designed for this company a system of mains of considerable novelty, which was severely criticised at the time, but has since proved most satisfactory.

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* Read before the Society of Arts, Wednesday, December 10th.

Culverts constructed with concrete or brickwork are laid under the pavements, and bare copper conductors, supported at intervals by glass insulators, are placed in these culverts. The conductors are composed of copper strips 1" by ¼", laid one over the other, so as to make up the total section required. In cases where there is no room under the pavement in which to build up the culvert, wrought-iron gas tubing is used, and cables insulated with thick vulcanised rubber are drawn through and connected to the bare conductors. Numerous service boxes are fixed in the pavements to enable houses to be connected without opening the ground. Four and a half miles of pipes with cables have been laid.

On the 1st December, lamps were connected to an equivalent of 24,850 32-watt lamps, and Mr. H. W. Miller, the company's engineer, to whom I am indebted for these particulars, informs me that the lamp supply, or maximum number of lamps in use at one moment, is between 30-40 per cent. of the lamp connection.

The House-to-House Electric Light Supply Company.

This company covers a large area, which consists of two dedetached districts, practically North Kensington and West Brompton. The generating station is situated off the Richmond Road, West Brompton, and contains space for a very large plant.

The Lowrie-Hall alternating current transformer system is adopted, with 2,000 volts on the mains. Four principal mains at present carry the current from the station, the transformers being connected to these mains where required. Cast-iron pipes are laid to form a conduit into which vulcanised india-rubber "Silvertown" cables are drawn; suitable manholes, covers, and junction-boxes being provided.

At present the demand for light is supplied from a plant, consisting of :—

Three "Babcock and Wilcox" boilers, working at 150 lbs. per square inch.

Three "Fowler" compound horizontal engines, each of 200 indicated horse-power.

Three "Lowrie-Hall" alternators, each of 100 units 2,000 volts.

Three "Elwell-Parker" exciters, each of 3 units.

The engines work at a speed of 88 revolutions per minute, each engine driving one alternator by seven cotton ropes, the exciter for each alternator being driven by cotton ropes from the alternator pulley.

The Lowrie-Hall" pressure regulator and recording instruments are also used. Mr. Hall, the company's manager, has kindly given me this information, and states that on their lamp connections, equivalent to 12,898 lamps of 8 candle-power, the maximum lamp supply is equivalent to 5,430 lamps of 8 candle-power—say, 42 per cent.

St. James and Pall Mall Electric Lighting Company.

This company was formed for the purpose of supplying the whole of the parish of St. James's, Westminster, and commenced to supply current under their provisional orders from their station in Mason's Yard, Duke Street, on April 4th, 1889.

The direct current is employed without batteries.

At present the above station supplies the southern half of the district, the total plant consisting of :—

Five "Davey-Paxman" boilers, working at 150 lbs. per square inch.

Two large Berryman feed water heaters.

Ten Willans's compound engines, each of 200 indicated horse-power.

Two Willans's compound engines, each of 80 indicated horse-power.

Twelve dynamos, "Latimer Clark, Muirhead & Co.," and "Siemens," driven direct from the engines.

The whole of this plant is neatly arranged, so as to occupy the least space.

The mains consist of a network of conductors on the three-wire system, supplied at about 100 volts at the station by suitable feeders. A cast iron trough or culvert is laid under the surface of the pavement, and three conductors, each consisting of a number of strips of bare copper, which can be added to at any time, are carried by porcelain bridges, placed at suitable intervals apart. To avoid any risk of the mains touching each other, porcelain distance pieces are placed over the mains. A cast iron lid, with water-tight joint, covers the trough. Connection to customers' houses is made by drawing well-insulated cable through gas tubing, which is screwed into the trough.

On the 5th December, a total, equivalent to 23,174 lamps of 8 candle-power, were connected. Mr. Dobson, the company's engineer, kindly informed me that the maximum lamp supply is equal to about 13,222 lamps of 8 candle-power—say 57 per cent.

The Westminster Electric Supply Corporation, Limited.

The district in which this corporation is authorised to supply electricity by its provisional order comprises that portion of the united parishes of St. Margaret and St. John, Westminster, which lies to the south of the centre line of the Metropolitan District Railway, and the portion of the St. George, Hanover Square, covering Belgravia and Mayfair.

The system adopted is similar to that of the Kensington and Knightsbridge Company, direct current in conjunction with batteries used as regulators, and also for supply during hours of minimum demand.

Three stations are being erected, one at Millbank Street, one at Eccleston Place, and one in Davies Street.

Current is now being supplied from the Millbank Street station and from a small temporary station in Dacre Street. The other two are being pushed forward as fast as possible, in order to supply from all stations early in the year.

Mains are being laid for a three-wire distribution, Messrs. Crompton being the contractors for the Westminster district, where the system adopted is similar to that put down by Mr. Crompton for the Kensington and Knightsbridge Company.

For other parts of the district Prof. Kennedy, the engineer to the company, has devised the following arrangement: bare copper strip rests on stoneware insulators placed from 6 to 8 feet apart, and bedded in the concrete culvert. The copper is stretched by a special tool before being pulled in, and this process gives it sufficient stiffness not to sag perceptibly between the insulators. The total sectional area of the conductors can be increased when required by the addition of more copper strip. Feeders are used in a most systematic manner, and Prof. Kennedy is to be congratulated on the favourable prospects of this company's work. There is a large demand for light in the district, and the rapid progress of this company justified the expectation of a speedy supply from the stations now in progress.

The London Electric Supply Corporation, Limited.

The Parliamentary powers possessed by this company cover a large area, comprising the district bordering the south side of the Thames from Westminster Bridge to Greenwich, Mayfair, Belgravia, St. James's and Pall Mall, St. Martin's-in-the-Fields, part of Westminster, Chelsea, and two isolated areas, namely, Newington and Clerkenwell.

The Ferranti system is employed throughout, alternating current being generated at an extra high pressure and transmitted to converting stations, from which it is distributed at high pressure to the service converters.

The corporation has erected a large station at Deptford, which has been admirably designed for the purpose, having road frontage, wharfage, and coaling dock. The plant consists of 24 "Babcock and Wilcox" boilers, four compound vertical engines by Hick Hargreaves & Co., two of which are 1,500 indicated horse-power each, and two of 750 indicated horse-power each. There is almost unlimited room for future extension.

Each of these engines drives a Ferranti dynamo by cotton ropes, the exciters being driven direct from independent engines.

In order to convey the high pressure from Deptford to London, Mr. Ferranti devised a special form of main for this purpose, which has been frequently described.

About 28 miles of these mains have been laid, the distributing mains from the converting stations being of various kinds. This company's Grosvenor Gallery station having lately been closed, a hurried change has had to be made in order to enable the corporation to supply from Deptford.

Chelsea Electricity Supply Company.

This company's provisional order covers the whole parish of Chelsea, a portion of which the company is now supplying.

Direct current is employed with accumulators, but, unlike the other companies in London, in this case the accumulators are charged with a high pressure current, and discharge direct at low pressure into the mains. I am not in possession of any information of this company's progress. From published descriptions you will doubtless be aware that the generating station is situated at Draycot Place, with battery stations at Clabon Mews, Egerton Mews, and Pavilion Road.

The Electricity Supply Corporation.

This company obtained a provisional order in 1889 for supplying the whole of the parish of St. Martin's-in-the Fields. Direct current, without batteries. The station is placed just off the Strand, and was laid down some years ago by Messrs. Gatti, to supply the Adelaide Gallery and the Adelphi Theatre; it is now being extended. At present the plant consists of :—

Four "Babcock and Wilcox" boilers.

Five Willans's engines, amounting to 600 indicated horse-power.

Five "Edison-Hopkinson" dynamos, each being driven direct from one engine. Callender mains are laid down in Callender-Webber casing.

St. Pancras Vestry.

The vestry have decided to carry out the electric lighting of the parish themselves, and have secured the able services of Prof. Robinson as their engineer. The direct current system will be adopted, and a station is now being erected in Stanhope Street, Euston Hoad, for the supply of the south-west portion of the parish.

Notting Hill Electric Lighting Company.

The provisional order granted to this company includes the district of Notting Hill, which comes within part of the parish of Kensington, St. Mary Abbot.

The system is similar to that adopted by the Kensington and Knightsbridge Company.

The first generating station, situated off High Street, Kensington, is now approaching completion, the plant consisting of Babcock and Wilcox boilers, Willans's engines, Crompton dynamos, and Howell batteries; Crompton's mains are also laid.

The Metropolitan Electric Supply Company.

The Parliamentary powers of this company include the large and important districts of Paddington and Marylebone parishes, with part of St. Martin's-in-the-Fields, the Holborn and Strand district, and St. Giles's Board of Works.

Various systems are employed by this company, both the alternating and direct current systems being adopted.

The company is at present supplying from four stations, and it may perhaps be better to describe them separately.

The Whitehall station, situated in Whitehall Avenue, is a direct current station which possesses no novelty, and supplies the surrounding locality, the plant consisting of Hick Hargreaves' boilers, Willans's engines, and Siemens' dynamos. Callender mains are laid down the Northumberland Avenue Subway and elsewhere.

The Sardinia Street station contains a complete plant on the Westinghouse alternating current system, consisting of twelve Babcock and Wilcox boilers, working at 150 lbs. per square inch; twelve Westinghouse alternators, each being belt-driven by a Westinghouse compound engine. There are also three exciters, each being belt-driven by its own engine.

The Manchester Square station contains nine Babcock and Wilcox boilers, ten Parker alternators, each driven direct by a 200 horse-power Willans's engine. There are also four exciters, each being driven direct by a Willans's engine The steam piping is arranged on a method devised by Mr. J. H. Rosenthal, the London manager of the Babcock and Wilcox Boiler Company, and possesses many advantages.

The Rathbone Place station contains plant of a similar kind, there being five boilers, six alternators and engines, two exciters and engines.

The system of distribution from the three latter alternating current stations is of a simple description—cast-iron pipes laid underground form conduits, into which "Silvertown" vulcanised rubber cables have been drawn when required. Split T-pieces are inserted in the pipes for connection to customers' premises. These mains are looped from house-to-house, returning to the station, so as to form complete rings. Each customer has, therefore, a duplicate supply, thus enabling new customers to be connected to the system without interrupting the supply on the circuit.

All these three stations are connected together by trunk mains, which enable one station to assist another, or take the whole load of the district during the hours of least demand. The current leaves each of these stations at a pressure of 1,000 volts, this moderate pressure being adopted as the number of supply stations reduces the distance to which each cable has to be laid to meet the demand. The whole supply is distributed by a number of small cables, which can be easily replaced when required.

The demand for light has been very encouraging; and, as you will see from the table,* the progress of the lamp connection to these stations has been very rapid. I regret, however, to say that, although this company at present supplies light to 12 public-houses, only four churches are, so far, connected with the system.

Having now completed our tour of the stations of the various companies, we have seen how the streets of London have lately been disturbed in order to lay all these mains; no doubt a certain amount of inconvenience has unavoidably been caused to traffic, but it has revealed the wonderful system of organisation by which London is governed; and the vestry surveyors, whose labours have been much increased, have not only afforded every facility for carrying out the work, but have rapidly re-instated the pavements at, of course, the cost of the respective electric light companies. The public, therefore, though for a short time inconvenienced, have in reality secured new pavements for old.

Summarising the plants adopted by the various supply companies, it is interesting to notice how the peculiar conditions of electrical supply in the very limited space usually available have been provided for by manufacturers. As an instance of this, it may be noted that "Willans's" engines, amounting to about 9,000 horse-power, are used by the public supply companies in London, and similar engines, aggregating more than 2,000 indicated horse-power, for private plants in the metropolis. The Babcock and Wilcox boiler having also been so universally adopted, it may be of interest to state that 78 boilers of this type, supplying 14,230 indicated horse-power, are now at work in London.

Private Plants.

One result of the Act of 1882 has undoubtedly been to cause a large number of private installations to be erected, but so many of our leading electric light contractors have laid down thoroughly efficient plants that there is perhaps no cause for regret. Most of the large terminal London railway stations work their own electric light machinery, the largest installation being at Paddington, where the Great Western Railway Company have machinery of 1,500 horse-power for this purpose. For residences, gas-engines provide the motive power for driving dynamos supplying about 18,000 lamps of 32 watts each, the remainder being steam-driven.

It may be of interest to note that the Crossley "Otto" gas engine, which was awarded a gold medal at this Society's recent motor competition, is being employed for this purpose, amongst others, by Messrs. Laing, Wharton and Down. This total may appear large, but it must be remembered that many of the large hotels having their own steam plant for working lifts, warming and cooking, have added electric lighting machinery; the total also includes the lamps at D'Oyly Carte's new theatre, where Messrs. Verity have erected a plant so complete, that it may almost be considered as a small central station.

Number of Incandescent Lamps now in Use in London.

With the kind assistance of the electric light contractors, particularly Messrs. Verity, Laing, Wharton and Down, Phipps and Dawson, Drake and Gorham, Sharp and Kent, and many others, and the public supply companies, I have been able to collect data that the total equivalent number of 32 watt lamps now in use in London is approximately as follows:—

Public supply companies	179,060
Private plants	85,000
Total	264,060

At the present rate of increase, a very moderate estimate gives an addition of at least 4,000 lamps per week, and there is little doubt that this number will be greatly exceeded at no distant date.

All these incandescent lamps have been calculated on a basis of 32 watts or 8 candle-power lamps, as experience has shown that this is a size much used in London, and, by taking the smallest lamp, we avoid dealing with half lamps.

Before leaving these particulars, it will probably be of service to the designers of future stations if we tabulate the data collected.

Table Showing Percentage of Maximum Lamp Supply at any Moment to Total Lamp Connection.

Station.	Percentage.
House-to-House	42
Kensington and Knightsbridge	30 to 40
St. James's and Pall Mall	57
Sardinia Street	45
Rathbone Place	64
Manchester Square	45

It perhaps may be of interest if I draw your attention to the following table, based upon data which has come under my observation, showing the candle-power of lamps mostly used:—

Lamps (50 Volts).

8 C.P.	16 C.P.	32 C.P.	50 C.P.	100 C.P.	200 C.P.	500 C.P.
597	1,666	62	13	8	8	3

Lamps (100 Volts)

5,437	5,131	176	26	57	40	3

During 1886 and part of 1887 I was able to collect the following data of the behaviour of incandescent lamps, each of 25 candle-power, with an efficiency of 3½ watts per candle, and I trust that more information of this kind will be collected.

With reference to arc lighting, considerable progress is being made; and, although the number now in use in London does not much exceed 1,000 lamps, there is no doubt that rapid progress will be made.

Prof. Silvanus Thompson, in March, 1889, showed you all the best known arc lamps; and, for further information of their development, I must refer you to his most complete paper on this subject, published in the Society's *Journal*, March 8th, 1889.

It is a matter for regret that there is no progress to be noticed in connection with the efficiency of the incandescent lamp, which remains much the same as it was five years ago. It will be apparent from the table showing the candle-power of lamps mostly used, that a really efficient 100-volt 8 candle-power lamp is much needed; the present lamps of this kind have such a short life that customers, contractors, and electric supply companies would all hail its advent as a boon.

We must also remember that the future progress of electric lighting depends in no small measure on the lamp-makers, and as the manufacture of the incandescent lamp will soon be open to all (owing to the expiration of the present patents), the absolute necessity of a standardising laboratory must compel its adoption where not only instruments but lamps can be tested, so that people may know when they ask for an 8 candle-power 100-volt lamp, with or without a guaranteed life of, say, 1,000 hours' at an efficiency of 3½ watts per candle, that they get what they have asked for.

That this question of lamp efficiency is of importance to cus

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* This table, giving particulars of the Electric Light Companies of London, we published last week as a special page.—EDS. ELEC. REV.

INCANDESCENT LAMPS.—LIFE AND NATURE OF FRACTURE.

All Lamps 25 C.P. Brass Collar, Edison-Swan.

Lamps.			Nature of failure.											
			Glass globe.						Filament fractured.					
Volts.	No. of lamps renewed.	Average life hours.	Broken.	Per cent.	Blackened.	Per cent.	Plaster.	Per cent.	Loop.	Per cent.	Stem.	Per cent.	Joint.	Per cent.
151	536	861	114	21·2	21	3·91	56	10·44	208	38·80	114	21·26	23	4·29
142	189	789	19	10·0	4	2·11	41	21·69	67	35·45	47	24·96	11	5·82
120	2,549	923	273	10·7	92	3·60	334	13·1	1,114	43·70	693	27·10	43	1·68
99	588	1,423	122	20·7	61	10·37	92	15·64	212	36·00	95	16·10	6	1·02
	3,862		528		178		523		1,601		949		83	
				13·67		4·61		13·54		41·46		24·57		2·15

tomers and supply companies alike few will doubt, and the following Table will probably explain itself :—

Watts per candle.	Candles per 1,000 watts.	Lamps per 1,000 watts.			
		8 C.P.	16 C.P.	20 C.P.	32 C.P.
2·00	500·0	62·5	31·2	25·0	15·6
2·25	444·5	55·5	27·7	22·2	13·9
2·50	400·0	50·0	25·0	20·0	12·5
2·75	363·6	45·4	22·7	18·2	11·4
3·00	333·3	41·7	20·8	16·7	10·4
3·25	307·6	38·4	19·2	15·4	9·6
3·50	285·7	35·7	17·8	14·3	8·9
3·75	266·6	33·3	16·7	13·3	8·3
4·00	250·0	31·2	15·6	12·5	7·8

We see, then, how an improved lamp efficiency will benefit the supply companies, by enabling them to increase their lamp connection.

The following Table will appeal most strongly to all users of the incandescent lamp; but it must be assumed that an increased efficiency is not obtained at the expense of a reduced life of the lamps.

The most satisfactory feature, however, of the present Edison-Swan lamps is the uniformity of their voltage; and the scientific department of the Edison and Swan Company's work is to be congratulated on the assistance they have given to the industry, by practically enabling voltmeters to be set by photometrical tests of the lamps.

Cost per Annum per 8 Candle-power lamp at 8d. per Unit, Lamps Burning an Average of :—

Per day.	½ hour per day.	1 hour per day.	2 hours per day.	3 hours per day.	4 hours per day.
Hours per Annum.	182·5	365	730	1,095	1,460

Cost per annum with lamp efficiency of :—

	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d	£	s.	d.
2 watts per candle	0	1	11	0	3	11	0	7	10	0	11	9	0	15	8
2·25 „	0	2	2	0	4	5	0	8	9	0	13	2	0	17	6
2·50 „	0	2	5	0	4	10	0	9	9	0	14	7	0	19	6
2·75 „	0	2	8	0	5	4	0	10	9	0	16	1	1	1	5
3·00 „	0	2	11	0	5	10	0	11	8	0	17	6	1	3	4
3·25 „	0	3	2	0	6	4	0	12	8	0	19	0	1	5	4
3·50 „	0	3	5	0	6	10	0	13	8	1	0	5	1	7	3
3·75 „	0	3	8	0	7	4	0	14	7	1	1	11	1	9	2
4·00 „	0	3	11	0	7	10	0	15	8	1	3	6	1	11	4

It may be thought that an estimated use of a lamp for only about 200 or 300 hours per annum is very low, but it should be remembered that the electric light need only be used when it is required, as the ease of switching it on and off makes us forget all our past troubles in hunting for gas-taps, matches, and broken gas globes. With ordinary care, the average cost of burning an 8 candle-power lamp for ordinary domestic use need not exceed ten shillings per annum.

Of course much depends on the wiring contractor, who not only has to be an accomplished art critic in designing or selecting the brackets, pendants, &c., but he has also to select the most advantageous positions for the lamps and switches. A switch placed near the door of every room, and not less than two lamps in any room, will probably save annoyance.

The greatest progress has been made in the wiring of houses. Not only is more work done, but it is better done, and on more mechanical principles, for whereas some years ago a single main would have been run from top to bottom of a house with numerous T-joints, independent circuits will now be wired, and all brought to a neat form of distributing board.

The effect of the extra care which is now taken with this work is proved by the following table of insulation tests, taken with 100 volts at 200 houses :—

Insulation Tests of Internal Wiring (Taken with 100 Volts—Evershed Ohmmeter.

Number of points.		Test megohms.
5 to 10	Average of 15 houses	4·0
10 „ 15	„ 23 „	3·5
15 „ 20	„ 18 „	2·8
20 „ 25	„ 13 „	2·7
25 „ 35	„ 33 „	1·8
35 „ 40	„ 12 „	1·5
40 „ 50	„ 16 „	1·2
50 „ 60	„ 12 „	1·1
60 „ 70	„ 9 „	1·0
70 „ 120	„ 14 „	·4
120 „ 220	„ 9 „	·25

I hoped to have been able to place before you some record of the improvement in the health of London, owing to the progress of electric lighting, but so much has already been said and published about it that further facts appear needless. It is simply melancholy to see so many of our churches and halls not only burning their gas jets for lighting, but also for "warming" the building. If culpable negligence amounts to manslaughter, the people responsible for this atrocity ought to receive their deserts.

Having now placed before you some account of the progress of electric lighting in London, I must ask you to compare our metropolis with other cities, and leave you to judge whether we are so very far behind them as some would have us believe. Is it not more probable that other countries will be glad to avail themselves of the experience which London must gain in the working of so many distinct systems?

DISCUSSION.

Mr. R. E. **CROMPTON** said that electric engineers might feel proud that, although they had been so heavily handicapped in the race, they had begun at last to bring London to the front, and it would not be long before they were as far ahead of any other town in the world in electric lighting as they were in most other respects. The Act of 1882 completely stopped electric lighting for several years, though, as engineer to the Edison and Swan Company, he then designed several central stations which, even in the light of present knowledge, he could say could have been carried out practically as well then as they could now. Five years ago a gentleman called at his office and said he was connected with an estate company which had a subway, so that underground mains could be laid without coming under the Act, and the result was the formation of the Kensington Court Company, his informant being Mr. Granville Ryder, the present chairman of the company. At that time not a single underground main had been tried, and but for this opportunity of testing the system, it was very improbable that either the Kensington Court Company, the Whitehall, or the Metropolitan Company would have occupied the positions they now did. The results then obtained led to the agitation which produced the amended Act. The public should know that though they might have been inconvenienced by the breaking up of the streets, it was a very different thing from similar annoyances on the part of gas and water companies, because in most cases the work was done once for all

Conduits or pipes had been laid, into which the conductors could be drawn, and from which they could be withdrawn and repaired, so that connections could be made without further breaking up of the road. He did not know the exact mileage, but he should think nearly 150 miles had already been laid, which was no small feat to accomplish since the provisional orders were obtained two years ago. In the system of underground conductors with which Mr. Bailey had connected his name—though he was by no means the sole inventor, many other engineers having contributed to its development—the idea was not only to give access to every house for the electric light, but to afford sufficient means of access for many other systems of conductors in future—telephone wires, fire alarms, and other means of communication, which would be greatly appreciated in future, and though the idea might now seem Utopian, he hoped the time would come when compressed air might also be supplied for the purpose of giving cool storage in every larder.

Prof. Kennedy, F.R.S., said this paper would be much quoted after a few years, for Mr. Bailey had given a most vivid picture of the state of electric lighting in London, just at the time when it was most interesting. As to the maximum number of lights at one time in use as compared to the total number on the station, he had been apparently very fortunate in one of his own districts. He had found in Westminster the usual average was about 40 to 42 per cent., but one foggy day in last week it went up to 60 or 61, judging from the amount of current going out. As to the state of electric lighting in London compared with other places, there was no other city in the world that had 250,000 lights, or anything like it. He believed it was about double the amount in use in New York, and before long people would be coming here for information, instead of scoffing at us for doing nothing. With regard to safety in working the station, he thought that there should always be power in reserve equal to one of the largest units; if 200 horse-power engines were the largest used, for instance, there would be 200 horse-power in reserve, but the use of one 500 horse-power engine necessitated at least 500 horse-power in reserve, and so on. He should be glad to think that putting a boiler on a lower level than the engine would ensure having dry steam, but rather doubted whether that was proved experimentally. If the particular boilers mentioned gave dry steam, he did not think it could be owing to their position in reference to the engine.

Prof. Forbes, F.R.S., asked what the black spider-like lines on the map indicated? Mr. Bailey had collected an enormous number of the very facts engineers wanted to arrive at, and he hoped other gentlemen connected with central stations would follow his example and give the result of their experience. Mr. Bailey seemed rather hurt because various people had criticised the progress of electric lighting in this country, and contrasted it unfavourably with what was done elsewhere, and perhaps few had done more in that way than he (Prof. Forbes) had. He had taken the pains to learn what was being done in foreign countries by personal inspection, and had frequently, on his return from such enquiries, done his best to impress on those concerned at home the superiority of the work that was being done abroad. The last time he had occasion to do so was about three years ago, when hardly any of the work now described had been commenced; but he now thoroughly endorsed what had been said by Prof. Kennedy, that there was not an example in the whole world of such enormous progress in so short a time. They were delayed for a long time by the former Act, but during all that time they were studying what was done elsewhere, so that when they begun they were on sure ground, and went ahead with more confidence than people elsewhere had done. Not only was the scale of work greater in London than anywhere else, but the character of the work in the central stations would bear comparison with any. Any one who had visited the Sardinia Street station would feel that it was as complete and satisfactory as it could possibly be.

Mr. W. M. Mordey said that he believed this paper would be of the greatest value. He suggested that it should be followed, at fairly frequent intervals, with other accounts of the work that was actually being done. He remarked that Mr. Bailey's particular arrangement of primary mains, which was very simple and ingenious, had not been alluded to in the paper. It would be very useful if they could have not only the relative life of 50 and 100-volt lamps, but their relative efficiency. It would be well to know how much the lowering of the candle-power of the former counter-balanced the advantage of the longer life, the blackening of the globe in a low voltage lamp being always more serious than in the case of a high one. A strong confirmation of what had fallen from the Chairman and Mr. Crompton as to the effect of the Act of 1882 was to be found in experience abroad. It was often stated that our knowledge of how to distribute electricity had greatly advanced since 1882. This was true, but it was also true that, so far as supplying lights in a densely inhabited district was concerned, no great advance had been made or was to be expected. As an illustration of this, he referred to Milan, where a large scheme had been carried out on the lines that were available in 1882. Just about 1883, a station was put down there which had never had the current off the mains for six years, and it was now supplying 25,000 16-candle-power lamps, on the direct low-tension system. The history of that station showed that, in a dense area, the old-fashioned system was very good in its way, even without the advantage of the three-wire arrangement. Distant places—suburbs, and so on—could not be supplied, but they were now supplying the more distant parts on the high-tension system, somewhat similar to that mainly used by Mr. Bailey's company. The history of the Metropolitan Company illustrated the advance in knowledge of how to distribute light over a large area economically, especially in the early stages of the work. That company started with a low-tension system and with batteries; but all the stations added since were on the high-tension system, without batteries. They knew now how to supply both in dense areas and over long distances. Mr. Crompton had, in London, perhaps done more than any one in the former direction, and the Metropolitan Company more than any one—except, perhaps, Mr. Ferranti—in the latter. A great deal had been said by Mr. Preece and others in that room on the advantage of lighting streets by arc lamps. It appeared that there were only about 1,000 in use in London altogether. He thought the general public would never fully appreciate the advantages of electric lighting until the whole of the main streets were illuminated in that way. Nothing had been said about the electric lighting of the City, no doubt for the reason that there was at present no lighting in the City. This reproach would shortly be removed, his company and others having undertaken a general lighting scheme, which, he was glad to say, included street lighting by arc lamps.

Mr. R. W. Wallace pointed out the great importance of endeavouring to improve incandescent lamps. He believed, from some experiments which had been made, that it would be possible to reduce the amount of current used in these lamps by about one-third, though the result might be to shorten the life of the lamp. But when one considered the value of the lamp compared with the price of the current for a number of hours, that would be but a small matter. He hoped, therefore, that inventors would turn their attention in this direction.

Mr. Chaplin said it would be very interesting to know if there were any data showing whether an incandescent lamp worked with a low-tension current had a much longer life than one worked with a high-tension.

Mr. Bailey, in reply, said that so far as he could ascertain there were now 81¼ miles of conduits of all kinds, in some cases pipes, in others concrete or brickwork; and into these conduits were led about 111¼ miles of cable, which were actually carrying current at the present moment; and that had practically been accomplished in 18 months, in order to supply the public with electric lighting, but they had not yet got to street lighting. That brought him to the question of arc lamps. Everyone would like to see arc lighting, but they could never expect to see it in London in such perfection as in Milan and other places where the streets were practically built for it. One could not imagine the Strand looking particularly handsome, even with the aid of arc lamps; it was quite different in Berlin, where they could be placed in the centre of the roadway on very high masts; but such as the streets of London were, they would be immensely improved by arc lighting, and he believed this would come shortly; and in place of the very meagre account of this system which he had been able to give, he hoped before long to hear someone else give a much more ample description of what was being done in this way. Everything was now ready for it, and he could not quite understand what kept it back. Prof. Kennedy had referred to the maximum percentage of supply to the total lamp connection, as to which you might take either the average or the heaviest day, the figures given in the paper being the heaviest lighting day in November; and he found that in all the districts from which he had collected information that the heaviest duty came on between four and five in the afternoon. (He exhibited a number of diagrams showing the varying amounts of current demanded during the day, plotted on a curve, taken at different stations and on different days, the highest point varying according as the district consisted mainly of offices, shops, or theatres and restaurants.) The black spider-like lines which Prof. Forbes referred to, showed overhead wires, and he desired to emphasise what he had said in the paper on this point. There were over 25 miles of these overhead lines, and he could not remember a single accident attributable to them. The prejudice which existed against them was due to the wretched work done in New York, where they neither suspended the wires nor properly insulated them, but left them to rot, and then people said how dangerous they were. Mr. Mordey had kindly alluded to the arrangement of mains which he was endeavouring to carry out, and which he (Mr. Bailey) did not allude to in the paper because he did not want to advertise himself. There was no particular novelty about it; they were merely acting on mechanical principles, and endeavouring to give people a double supply, one from each end of the cable, so that when a new customer wanted to come on, there was no need to go round to all the subscribers and tell them they must be shut off. With reference to the incandescent lamps, he hoped others would keep a record of the behaviour of all the lamps under their charge, which could easily be done. He had an India-rubber stamp, with a movable date, which was stamped on the cement when the lamp was sent out; when it failed, and was brought in to be replaced, the storekeeper could tabulate the date and the fracture in the filament, and these records would be very valuable. In a few years' time it would be open to anyone to make lamps; and people then would buy from those who produced the cheapest and most durable. Mr. Mordey had referred to the Whitehall Company, and the alteration they had introduced in the other districts as the system developed. That was due to the size of the districts which that company had to light; it was not only a question of providing light, but of doing it quickly, for nowadays, as soon as anyone had his place wired, he wanted the current the next day; and if he did not get it, he worried the life out of the unfortunate engineer to the supply company. He hoped, before long, someone would read a paper showing the benefit to the health of the people conferred by electric lighting, the decrease in headaches and in doctors' bills. The other day a certain firm took proceedings against an electric light company for not continuing the supply, and stated on oath that whereas with the electric light they could go for six years without decorating their premises, when using gas they had to paint and whitewash every two years, and they claimed damages in consequence. He hoped the vestries would soon see the advisability of lighting the streets by arc lamps.

The CHAIRMAN, in proposing a vote of thanks to Mr. Bailey, said he prophesied two years ago that in ten years time 90 per cent. of all the houses in the West End of London, of £400 a year rental and upwards, would be lit by electricity. He now began to think that he had not been sufficiently sanguine, and that he might have mentioned a rental of £300 instead of £400. So long as gas was supplied at 2s. 9d. or 2s. 6d. per 1,000 feet, the electric light, until improved in some way—and the only improvement that seemed possible was economy in the lamp—must be a light of luxury; but persons who would pay £300 or £400 a year rent, were willing to pay £20, £30, or even £40 more for electric lighting, as compared, not with gas, because many would not use it, but with the other illuminants they employed. After a year's experience of the use of a number of lamps equal to about 114 8-candle lamps, he found the extra cost was between £20 and £25, as compared with the gas, candles, and lamps he used before, and in that he made no allowance for decreased expenditure in cleaning, painting, and matters of that kind, which was undoubtedly considerable. He had also a curious experience, during the summer quarter, of the truth of what Mr. Bailey said about the ease with which the electric light was extinguished and re-lighted. His summer quarter's bill for electric lighting was only a few shillings in excess of the gas bill for the previous year's summer quarter, and he bought no candles or lamp oil, having the electric light all over the house. The reason was simply this, that in a dark London basement, even in the summer time, the gas was kept constantly burning, but the electric light was turned out when not wanted, and though no doubt it was considerably dearer than gas, so much less of it was used, even by the servants, that it only cost a few shillings more.

ELECTRIC LIGHTING OF THE NEW OLYMPIC THEATRE.

THE new Olympic Theatre, which is situated at the south end of Drury Lane, is now completed, and was opened to the public a fortnight ago. It has been erected, from the designs of Messrs. Crewe and Sprague, by Messrs. Holliday and Greenwood. The theatre is probably one of the safest in the metropolis, there being no less than 18 exits, and ample space everywhere for the comfort of playgoers. It has a lofty auditorium, which, by the aid of a sunlight in the centre, assists in ensuring efficient ventilation. Following the example set by the proprietors of other London theatres, Mr. Chas. Wilmot, who has provided the house for Mr. Wilson Barrett, decided to have it lighted electrically, and Mr. Harry South, of 10 and 12, Garrick Street, W.C., was commissioned to do the work.

The installation is not at present quite completed, but when finished it will comprise about 1,750 incandescent lamps, averaging 16 C.P. The boiler and engine rooms are situated in the basement of the building below the scene dock, and well removed from the auditorium, both being very compactly arranged. In the former are erected two Davey-Paxman locomotive type boilers of 60 H.P. each, working at a pressure of 120 lbs. to the square inch. In the same room the feed pumps and injectors are erected, the latter being worked by exhaust steam, by means of which water is fed to the boilers at a temperature from 190° to 200°.

The engine room contains three compound high speed engines, each of 40 H.P., which were specially constructed for the installation to run at a speed of 390 revolutions per minute. Two of these engines are coupled to corresponding dynamo shafts, which are driven direct; but lack of space prevents the same arrangement being carried out with the third set. In the latter case the dynamo is driven from the engine by ropes, the speed being increased by this means to 550 revolutions per minute. The output of each machine is about 300 ampères, at an E.M.F. of 110 volts.

The main conductors are led to a distributing switchboard, and are divided so that any one, any two, or all three sets can supply any one circuit. The question of which arrangement should be adopted is determined by the "checks" in the piece, in such a way that any sudden alteration in the load, owing to dark scenes, &c., is immediately distributed over the second or third plant, if the particular one on which it is being run varies beyond a certain limit.

There are in all 45 circuits, each stage section being again divided into three at the "colour board," where the three different colours in which the stage is connected, unite. At the side of this is erected the checking board and resistances, the latter being of an entirely new design, and particulars of which are at present unobtainable.

Continuous practice in theatre lighting has induced Mr. South to seek patented protection for a number of ideas specially applicable to theatre work. These include a novel form of batten, only 6 inches wide and weighing only 2 cwt., a method of separate connection, &c., all of which are brought into use at the New Olympic Theatre.

NOTES.

Electric Lighting of Preston.—During the last six weeks the National Electric Supply Company, Limited, has erected, temporarily, overhead wires, and installed some 300 incandescent lamps' besides arc lamps, in several shops and places. The lights were started for the first time on Thursday last, and created a most favourable impression in the town. The commencement has been a great success, and there is no doubt that the company's present venture here will lead to extensive future business. The whole of the work has been carried out by Mr. F. F. Bennett, late district manager of the National Telephone Company.

Electric Light in Exeter.—The City Council had under consideration last week the advisability of applying to the Board of Trade for a provisional order. A letter was read from the secretary of the electric light company, explaining its position with regard to the matter, stating that the company was a local one, and that every effort had been made to meet the wishes of the council. After a long discussion it was decided by a large majority that the council should apply for a provisional order.

Ship Lighting.—The Norddeutscher Lloyds' ss. *Gera* left the Clyde on Saturday for Bremerhaven, after going through a series of speed trials in the Forth. The vessel is intended for the emigration trade between the Continent of Europe and South America. An extensive installation of electric lights have been fitted up, and is available in all the passenger departments as well as in other parts of the ship. On the same day the Fairfield Shipbuilding and Engineering Company, Limited, launched the *Oldenburg* for the same company. This vessel will also be lighted throughout by electricity, provided by three engines and dynamos, each furnishing power for 365 incandescent lights. On Saturday afternoon the Palmer Shipbuilding and Iron Company launched at the Howden yard H.M. cruiser the *Pique*, the first of three second-class cruisers placed by the Admiralty with the Palmer Company. The *Pique* will have a complete installation of the electric light.

Electric Lighting of Inverary Castle.—Sometime ago the electric light was introduced into several of the rooms in Inverary Castle. We understand the Duke of Argyll now purposes lighting the whole of his castle by electricity.

Electric Light in Berlin.—The Berlin Electric Lighting Company now supplies current for 100,000 8-candle-power incandescent lamps, and for 3,000 arc lamps, the total current supplied being 60,000 ampères.

"The Worst-lighted Town in England."—At a meeting of the Plymouth Town Council, says a local paper, where public lighting came up for discussion, a councillor expressed the opinion that "they could go into any other town in England and it was better lit than Plymouth." There is an electric lighting company there, but it is beset by financial difficulties.

Bristol and the Electric Light.—Last week the members of the Electrical Committee of the Bristol Town Council journeyed to Bath for the purpose of inspecting the installation of the electric light. On arriving at the works they were met by Mr. H. G. Massingham (the proprietor), Mr. Hooker (chief engineer), and Mr. W. H. Preece, and conducted over the works. Subsequently the deputation made a *detour* of the city and acquainted themselves with the public lighting of the streets in addition to the private supply, expressing their unanimous satisfaction with everything they had witnessed. On Saturday the committee held a consultation in Bristol with Mr. Preece. A site for the installation was approved, and Mr. Preece gave it as his opinion that at first the light in Bristol ought to cost very little more than gas, and eventually it would be cheaper, if the corporation managed the supply. Mr. Preece went over the area—from the Victoria Rooms to Temple Meads Station—proposed to be lit, and was instructed to prepare estimates for an installation equal to 60 powerful arc lamps and 10,000 incandescent lights. The scheme, in its present form, is larger than was originally contemplated; but the committee are advised that the period for mere experiment has expired, and they are therefore determined to recommend the council to adopt a system of lighting that shall be permanent, and that shall be so successful as to ensure its very general use throughout the city and suburbs before many years have passed.

The City and the Electric Light.—A meeting of the Commissioners of Sewers was held on Tuesday in the Guildhall, when the Streets' Committee brought up a report recommending that the supplying of the western district of the City with the electric light should be entrusted to the Brush Electrical Engineering Company, upon the same terms that they had undertaken to supply the central district. After discussion, Mr. Pannell, who has been one of the principal movers in this matter in the City during the last six years, congratulated the Commission that when this contract was made, two-thirds of the City would have the benefit of the electric light. The report was carried. It was referred to the committee to consider as to the alleged danger of storing electric power.

Croydon and the Electric Light. — The County Council has received from Mr. W. H. Preece a detailed report as to the requirements for the probable cost of laying down the electric light in the town. He estimates that a total length of 100 miles of mains will be necessary for the service of the whole district, of which 60 miles can be underground, and 40 miles overhead, the latter being for public lighting only. The underground mains will cost about £700 per mile, the overhead about £230 per mile. To this must be added £2,500 for the feeding mains. The laying of all the mains underground would cost £60,500, or an extra £6,800. In addition to the above-mentioned amounts it will be necessary to provide the installations. Under these circumstances the corporation have decided, in their application to the Board of Trade, to mention £150,000 as the amount of capital which may be employed.

The Folkestone Electric Light Committee.—The town clerk states that, instead of the town being put to "the enormous expense of £700" by this committee, as stated at a public meeting, the legal and incidental expenses have not exceeded £120; in addition to which £50 has been paid to Mr. Preece for his opinion on the subject.

The Barnet Electric Lighting.—Now that the local authority has determined to end its contract with Mr. Joel, and as his intended application to the Board of Trade for power to supply the light in the district of the East Barnet Valley Local Board has met with no support from that body, we feel interested to learn what the next scene in this little "Comedy of Errors" will divulge. It seems that a return to gas is generally desired.

London Theatre Lighting.—The London County Council, debating on the subject of the electric lighting arrangements of the London theatres, has decided to engage Dr. Hopkinson, F.R.S., to report upon the danger, if any, of all the various systems in use. Mr. A. L. Steavenson has written on the subject of the dangers of electric lighting to a Leeds newspaper, recounting his own experience of fires caused by electric light plant in connection with collieries, and he states that a few weeks ago another colliery owner told him that since he had adopted electric lighting there had been two fires, the commencement of the last being actually witnessed by the manager. Yet the *World* states that danger from electric lighting is a sheer delusion. What a world we live in!

The Electric Lighting Question in Maidstone.—At a special meeting of the Maidstone Local Board, last week, it was resolved to apply to the Board of Trade for a provisional order. A request, asking the Local Board's assent, authorising the Electric Installation and Maintenance Company to obtain an order for lighting the borough, was refused.

Serious Accident to Mr. Bernard Drake.—On Friday last, Mr. Bernard Drake, of Drake and Gorham, met with a serious accident while inspecting the large electric light installation which the firm are just completing for the police authorities at the new Scotland Yard offices. After leaving the Receiver of Police, Mr. Drake passed out of the building by a door leading into the courtyard, which was left ajar, and immediately fell a distance of some 15 feet down an open area, the replacement of the grating of which had been inadvertently omitted. About half an hour elapsed before it was possible to extricate him from the confined space into which he had fallen; but he was eventually conveyed to the Westminster Hospital, where he was found to be suffering from a broken thigh and other injuries. We are informed that he will be confined to his bed for at least two months, and it will naturally be a great disappointment to him to be unable to superintend the completion of the work to which the firm has devoted so much attention during the past six months. We sincerely regret the very serious misfortune which will keep Mr. Drake so long confined, and we trust that his recovery may be complete. With Mr. Gorham we heartily sympathise in being so unfortunately deprived of the valuable services of his active and able partner.

Commercial Cable Company.—The *Canadian Gazette* of the 11th inst. says:—Our readers know the high opinion we hold as to these shares, and we are glad to state that at a recent meeting of the directors it was decided to raise the dividend from 6 to 7 per cent. per annum, beginning with the payment to be made the 1st of January next. At the same time the bonds to be drawn in respect of the year now closing will not be £40,000, as heretofore, but £120,000. In addition, there will be a very large surplus to be carried to reserve account.

Boilers.—Messrs. Ewen & Co., of Walbrook House, have just issued a revised edition of the section of their illustrated catalogue dealing specially with engines and boilers. With reference to the latter, they draw attention to their loco-type multitubular boilers, which they construct to steam at any pressure according to requirements. In all cases all plate edges are planed, all holes drilled in position, and the riveting and plate bending effected by hydraulic pressure.

Junior Engineering Society.—On Saturday the 6th inst., over a hundred members of this society and their friends made an excursion to the Central Institution. According to the printed programme they were received by Professor W. E. Ayrton, vice-president of the society, and were conducted by him over various rooms. In these were displayed a variety of electrical and other apparatus, experiments were performed, and the methods of testing the power and efficiency of arc and incandescent lamps were shown. The busy afternoon was brought to a close in the large lecture theatre. Here the guests seemed much interested in watching the working of a Telpher model. The vote of thanks, which was called for by Mr. Tennant, the energetic chairman of the society, was carried unanimously; and, after it had been suitably acknowledged by Professor Ayrton, the company dispersed.

Lighting of Steamship Offices.—The Calcutta offices of Messrs. Mackinnon, Mackenzie & Co., the managing agents in India of the British India Steam Navigation Company, Limited, have been fitted with a complete installation of electric light. The generating plant consists of a "Marshall" 12 N.H.P. compound steam engine erected on a wrought iron frame underneath a locomotive multitubular boiler. The engine drives by belt a "Manchester" compound wound dynamo having an output of 100 volts, 180 ampères, at a speed of 800 revolutions per minute. Throughout the offices, 140 32 candle-power lamps are fixed. The entire work has been carried out by the electrical department of the B.I.S.N. Company's workshops, Calcutta, under the superintendence of Mr. R. J. Browne, the company's electrician.

Electric Light in Cornwall.—The electric light has been successfully started at the Kennal Vale Paper Mill, near Ponsanooth (S. J. Polkinhorn). The dynamo was supplied, and the work most efficiently carried out, by Mr. C. J. Veale, of St. Austell. The dynamo is driven by a small 8-inch "Little Giant" horizontal turbine, weighing some 3 cwt., supplied by Mr. S. Howes, which develops six-horse power under a fall of 24 feet, carried by a flume 12 inches diameter, although the power required for driving the dynamo is only some one and a half horse power. This being the first installation in the district, it has excited considerable interest.

Freeman and Son's granite works at Penryn, which have hitherto been lighted by Wells's and other oil lamps, are now lighted electrically.

Browett, Lindley & Co., Limited.—The firm of Browett, Lindley & Co., has been converted into a company under the style of Browett, Lindley & Co., Limited, with a view to the immediate extension of plant and manufacturing facilities to meet the increasing demand for their patent "Acme" governors and specialities in high-class steam engines for electric lighting and other purposes. The *personnel* of the firm is in no way altered by the change, as the principals of the late firm are the managing directors of the company.

Reform Club.—This club is to be lighted by electricity.

The Royal Society.—Last night Messrs. H. L. Callendar and E. H. Griffiths were to read papers on the determination of the boiling point of sulphur and on a method of standardising platinum resistance thermometers by reference to it.

General Electric Power and Traction Company.—During the five months ending November, the electric cars of this company operating on the Barking Road section of the North Metropolitan Tramway Company's lines ran 27,597½ out of a possible 27,833 miles. On the 28th of last month, when there was a heavy fall of snow, the cars ran 193 miles out of a possible 213—a better average than was made by the horse cars.

German Readers Please Note.—An envelope, much torn, apparently from Berlin, was received, minus contents, by us on the 15th inst. If any one in Germany is awaiting an overdue reply, will he kindly send us a line to that effect.—[Eds. Elec. Rev.]

International Exhibition, Moscow.—A scheme is on foot for establishing a permanent general exhibition in the chief commercial city of Russia. Sales will be effected, and orders taken from samples. The agent in this country is M. Emile Cloes, C.E., 122, Cannon Street.

Lightning and the Electric Light.—A panic was produced a few days since in the town of Trente (Germany). After a heavy snowstorm, the lightning struck the building which supplied the electric light to the town, and darkness immediately followed. There was, however, more fear than danger, as the light was again available within a few minutes. A performance was taking place at the Teatro Sociale. The audience remained quiet, and the actors, preserving their presence of mind, continued their parts, without interruption, in the darkness.

Electric Light in Madrid.—Two companies, one English the other German, have recently obtained concessions for lighting districts in Madrid. The first-mentioned company has received applications for 6,000 lamps; its distribution is by alternating currents. The second employs continuous currents, and has been assured of a minimum service of 11,000 lamps; its station will be fitted with dynamos for the supply of current for 22,000 lamps, and it will be provided with Tudor accumulators, so as to bring the total number of lights up to 40,000.

Personal.—The *Elektrotechnische Zeitschrift* states that Lord Rayleigh has been elected honorary member of the Bavarian Academy of Science.

Electric Organ in Verona.—An electric organ has been erected in the S. Giorgio Church in Verona by Mr. G. W. Trice, of Genoa.

Dr. Coffin's Electric Welding Process.—It is reported that the English promoters of this process are about to establish works in or near London.

Smoking Concerts in Favour.—The staff of the General Electric Company held their first smoking concert at the Champion Hotel, Aldersgate Street, on Friday, the 12th inst. The chair was occupied by Mr. H. Hirst, and there was a large attendance, which included a number of well known friends of the firm. An excellent programme was gone through, including an exhibition of the gramaphone, which excited considerable interest. It is proposed to hold the next concert on January 23rd, 1891.

The National Telephone Electrical Society—Midland Branch.—On Friday, December 5th, in connection with this Society, the President (Mr. Alfred Coleman) in the chair, the Vice-President (Mr. A. E. Cotterell, district manager) gave a very interesting and instructive paper on "A Few Errant Notions on Telephonic Matters." The paper was listened to by a large number of members, and was much appreciated. The Presidential Address was delivered by the President on Friday, November 21st, on "Telephony at the Present Time."

Quanti est Sapere.—We are glad to notify that the Council of the Institution of Electrical Engineers has awarded Mr. W. B. Esson the "Institution Premium," for his paper on "Some points in Dynamo and Motor design." This grant, together with his recent accession to the dignity of President of the Old Students' Association, will give Mr. Esson an earnest of the honours which are yet to be showered upon him. May he bear them modestly!

"L'Electricien."—From the 1st of January, 1891, *L'Electricien* and the *Revue Internationale de L'Electricite*, which have hitherto been published as separate journals, will appear as one, under the joint titles of the two. M. Hospitalier, we regret to say, owing to the pressure of other work, is unable to continue the editorship.

O.S.A. Cinderella Dance.—On Friday evening last a very enjoyable and successful dance was held at the Westminster Town Hall, in connection with the Old Students' Association of the City and Guilds of London Institute. Over 120 were present. In connection with the association, it may be mentioned that an excellent programme has been drawn up for the New Year, including four papers, three concerts, &c.

An Important Event.—The General Manager and Secretary of the St. James' and Pall Mall Electric Light Company sends us the following note, dated December 17th, but what bearing it has upon the subject of electric lighting is more than we can divine:—"The Right Hon. A. J. Balfour, M.P., and Mr. G. W. Balfour, M.P., this evening visited the central station at Mason's Yard, Duke Street, Piccadilly." We may soon expect to hear that Mr. Parnell has inspected the fire escapes at the headquarters of the London Fire Brigade, or that Sir Charles Russell and Mr. Gill have entered into a partnership with the object of placing before the public a financial newspaper on the commercial morality of which one may absolutely rely.

Ferranti Mains.—Touching the remarks we have made on p. 734 on "High Pressure Alternating Mains," it may not be generally known that Mr. Ferranti uses two of his concentric cables side by side with the inner copper tubes connected together in parallel as one lead and the two exterior tubes similarly joined up as the other.

Gas v. Electricity at Lewes.—The result of the poll of the ratepayers of Lewes on the question of adopting electric lighting for the public thoroughfares, has been a majority of 25 for gas; the numbers being 177 for this illuminant against 152 for the newer one proposed.

The City and South London Railway.—This electric line, the opening of which has been twice prematurely announced, commenced operations yesterday morning. We wish success to everybody concerned.

The Globe Electrical and Engineering Company.—We are informed that the business of this company has been transferred to the Electrical Supplies and Fittings Company, Limited, having offices and stores at 2, Carteret Street, Westminster, who are about to issue a catalogue of electrical supplies comprising particulars of their well known manufactures, and of a series of specialities for high and low tension distribution.

Engines and Boilers.—A reference to Mr. Bailey's Society of Arts paper will show the rapid development in London of the Babcock and Wilcox boilers and Willans's engines.

A Correction.—In our reference last week to the *Oracle*, when mentioning the Electric Construction Corporation, it was intended to refer our readers to our contemporary's pages for Monday, the 8th inst.

Telegraph Expenditure.—A report issued on the 18th inst., states that the total expenditure on telegraphs for the year ended March 31st, 1890, was £2,568,799.

Russian Telegraphs.—The staff of the Russian telegraph service has under deliberation the construction of a telegraph line along the shore of the White Sea between Kala and the Norwegian frontier. The only present means of communication is a bi-weekly postal service.

Incandescent Lamp Renovation.—We understand that Messrs. E. Böhm & Co., of Little Britain, are devoting attention to a process for lengthening the life of incandescent lamps. Discoloured bulbs can be opened and cleaned without interference with filaments or mounting, and it is said that when a lamp is thus treated, and re-exhausted and sealed, it is more durable than a new one.

The Paris Electric Lighting Companies.—The four principal electric light companies in Paris, who hold concessions for 18 years from the Town Council, are following the example of the Paris Gas Company, by seeking to obtain an extension of their powers to the year 1930. For this purpose they have submitted to the municipality a memorial offering to reduce the price charged for the electric light, provided their concessions are prolonged to that year. The memorial is under the consideration of the Third Committee of the Council.

Electrical Industries in the United States.—The following figures will give an approximate idea of the present development, in the United States, of those industries in which electricity is the chief factor, and which seem to necessitate addition almost every day.

			Force in H.P.
Arc lights	(number about)	235,000	475,000
Incandescence lamps	"	3,000,000	
Electric motors	"	18,000	75,000
" railways	"	300	
" " carriages	"	2,500	
" " length of lines		280 miles	

Electric Light and Power in a Village of 465 Inhabitants.—Collais, near Nimes, a village of 465 inhabitants, has just been lighted by electricity. The motive power for the 1,600 light dynamo is derived from a small waterfall. The streets are lighted by 25 lamps of 16 candle-power each. Besides lighting the village, the current is employed during the day in putting in motion the pumps for supplying certain parts of the village with water.

The Electrical Lighting of the Diamond Mines.—The installation for the lighting of the underground workings of the Central Diamond Mine, Kimberley, has just been completed, under the superintendence of Mr. R. Oliver G. Drummond. From the second annual report for the year ending 31st March, we find the De Beer's Mine circuit had been running about 15½ months, night and day, with the exception of a short stoppage on Sunday, and during that period there had been no cessation to the light, during working hours, except once, when the engine had to be stopped for 10 minutes to remake a joint. The plant from which the Central Mine is worked is situated within the mining area of the De Beer's Mine, and the company have obtained the right to run their wires through the busiest thoroughfares of the city, from one station to the other, so that they have every facility for lighting the club, public library, post office, court house, and their own private central offices in the diamond market, very cheaply, which they propose to utilise. Many of the large mercantile stores on the route are in treaty with the company, and will probably be supplied from the same source. The Masonic Temple is already lighted from the De Beer's station, and although more than a mile distant, by a system of electrical signals and switches, each ceremony is methodically illuminated, according to ancient custom, without the slightest hitch.

NEW COMPANIES REGISTERED.

J. Tylor & Sons, Limited.—Capital, £100,000 in £10 shares. Objects: To carry on business as mechanical, consulting, sanitary, hydraulic and electrical engineers and contractors, manufacturers of electrical plant and apparatus, waterworks fittings, &c. Signatories (with one share each): *W. H. Tylor, *Joseph John Tylor, C.E., * W. B. H. Drayson, * Philip Bright, J. S. Maples, W. S. Salter, Thos. Allsop, all of 2, Newgate Street. The first four of the signatories are appointed directors. Qualification : 100 shares. Remuneration of ordinary directors, £60 per annum each. Mr. Joseph John Tylor is appointed chairman and consulting engineer, and Messrs. W. B. H. Drayson and P. Bright are appointed managing directors, upon terms to be agreed. Registered 8th inst by Sydney Morse, 4, Fenchurch Avenue. Registered office, 2, Newgate Street.

Foreign Electric Date and Time Stamp Company, Limited.—Capital £100,000 in £1 shares. Objects :—To acquire an invention of an electro-mechanical date and time stamps, patents for which have been obtained in France and Italy. Signatories (with one share each) : E. Berlin, 17, All Saints' Road, W. ; J. R. Akerman, 139, Minories ; J. P. Nurse, 16, Barford Road, Nunhead ; G. J. Pocock, 4, Oswyth Road, S.E. ; J. L. Stevens, 90 and 91, Queen Street ; E. G. Taylor, 46, Brighton Road. The signatories are to appoint the first directors ; qualification, £100 in shares ; remuneration, £600 per annum, divisible. Registered 8th inst., by F. Fearon, 25, Parliament Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

J. E. H. Gordon and Company, Limited.—An agreement of 15th September (filed 1st October), provides for the purchase by the company from J. E. H. Gordon, of 11, Pall Mall, and Wm. John Rivington, of 21, Gledhow Gardens, Kensington, the business of electrical engineer and contractor for the construction and supply of electric light machinery and apparatus, carried on by Mr. J. E. H. Gordon, at 11, Pall Mall. The purchase consideration is £30,000 in fully paid shares. The vendors are appointed joint managing directors for life, each of them to receive a salary of £1,500 per annum.

Williamson Electrical Engineering Co., Limited.—The annual return of this company, made up to the 12th inst., was filed on the 13th inst. The nominal capital is £5,000, in £10 shares. 250 shares are taken, and upon these £7 10s. per share has been called and paid, the paid-up capital thus being £1,875. Registered office, 14, St. Ann Square, Manchester.

Blackpool Electric Tramway Company, Limited.—The annual return of this company, made up to the 12th inst., was filed on the 13th inst. The nominal capital is £30,000, in £10 shares. The whole of the shares are taken up, 150 being considered fully paid up. Upon 2,850 shares the sum of £6 10s. per share has been called, the calls paid amounting to £18,525.

Woodhouse and Rawson United, Limited.—An agreement of 10th inst. (filed 11th inst.), between this company and James Thorne, of 85, Gracechurch Street, cites that by an indenture of 11th February, 1890, it was agreed to issue to the said James Thorne 100 fully paid preference shares, in consideration of the conveyance to the company of a certain invention and letters patent. The said preference shares were duly issued on the 7th February, but 36 of such shares have since been surrendered to the company, and have been cancelled, leaving still issued 64. Although an agreement for the issue of such shares was duly filed, such agreement does not define the distinguishing numbers of such shares, and it has therefore been considered advisable to file an agreement defining such numbers. The said shares are therefore numbered, by the present agreement, from 61,701 to 61,800 inclusive.

Woodward, Grosvenor, and Company, Limited (carpet manufacturers, manufacturing chemists, electricians, &c). The statutory return of this company, made up to the 12th ult., was filed 24th ult. The nominal capital is £90,000, divided into 6,000 ordinary and 3,000 preference shares of £10 each, 5,000 of the ordinary, and the whole of the preference shares, are taken up, the former being considered fully paid up. Upon the preference shares the full amount has been called, the total of the calls paid being £21,900, and unpaid £8,100.

Franco-African Lighting Syndicate, Limited.—At a special meeting of this company, held at 3, Bucklersbury, on the 19th August, it was resolved that the net profits be devoted, firstly, in payment of 10 per cent. per annum cumulative preference dividend, the balance to be distributed amongst the holders of the ordinary shares. If the syndicate be wound up, the surplus assets shall be applied, in the first place, in repaying to the holders of the preference shares the amount paid up thereon, and the residue shall belong to the holders of the ordinary shares. These resolutions were confirmed on the 9th September.

Earthy Metals Company, Limited (metallurgists, manufacturing chemists, and electricians).—An agreement of 10th ult. (filed 4th inst.) provides for the purchase by the company from Louis Falero, of 100, Fellows Road, M.F.S.I.E., chemist and electrical engineer, of certain secret processes and inventions for the production, isolation, refinement, and preservation in the metallic state of sodium, potassium, magnesium, and aluminium, and also patent rights in connection therewith. The purchase consideration is 20 fully-paid deferred shares of £50 each. The vendor is appointed managing director for five years. His remuneration is to be an annual amount not exceeding £5,000, as may be equal to one-twentieth part of the consideration to be paid in cash or shares by a new company to be formed, within five years, for acquiring the property and undertakings of the present company.

The statutory return of the company, made up to the 24th ult., was filed on the 5th inst. The nominal capital is £2,000, in £50 shares. 38 shares are taken up, 20 of these being issued as fully paid up. Upon 18 shares the sum of £750 has been paid, leaving £150 unpaid. Registered office, 1, Westbourne Terrace, Willesden Green, N.W.

CITY NOTES, REPORTS, MEETINGS, &c.

The Gülcher (New) Electric Light and Power Company.

At the third ordinary general meeting, held at Winchester House yesterday, Mr. de. Castro addressing the meeting, referred to the presence of the reporters. Last year he had a little difficulty with one of the representatives of the press as to whether their meeting was private or public. His view was that it was a meeting of shareholders, and that the public were not interested in the concern, as they were not quoted on the Stock Exchange. It was a question, however, which rested with the shareholders.

A Shareholder considered that it was going back a little to exclude reporters. Other meetings of a like nature were thrown open, and further, as they were nearly in a position to apply for a quotation, it would not be an advantage to exclude the press, he therefore proposed the admission, which was seconded and carried.

The Chairman, in making a few observations, said the period since June had been a very important one for the company. On the date mentioned they had the very small preference capital, comparatively, of £50,000; they had £12,277 subscribed (shown by the report published in the Review last week). They had also a further £6,000 second mortgage debentures, which they were obliged to raise in order to meet the extraordinary difficulty the company was placed in by a contract entered into in New Zealand. He was glad to say that things now were entirely different. They had found that, however prosperous a company might be, or whatever its prospects were, it was hopeless to expect that a company with so small a capital and burdened with such heavy mortgages—£16,000 of them bearing such a very heavy rate of interest—to declare dividends. To pay off the heavy debentures it was necessary to issue the balance of the capital ; they accordingly issued the balance of the preference capital, amounting to £37,723. The whole had been subscribed very largely by those who held 10 per cent. debentures, also by new shareholders, who formed an excellent list. The capital, therefore, now stood as the report indicated. They would all admit that they had attained a position which neither the old nor the new companies had ever attained before. The business to which he referred as having plunged the company into difficulties was the undertaking by mistake of a contract by the late manager, which cost over £13,000, being six times more than was estimated. This accordingly locked up a large sum of money. Looking at the business of the company, he would state at the outset that they were a manufacturing electrical engineering company; they did not supply electricity. The capital required for such a company was much greater. The capital, £136,500, invested in their own concern, left alone, would not pay, it would not produce an income proportionate to the outlay, even if they consented to lock it up; to make it pay, it would be necessary to lay out another £9,000 to produce a substantial interest upon the £25,000 or £26,000. Under these circumstances, it became a matter for the serious consideration of the board as to whether they should employ the uncalled capital. They decided in the early part of the year, if they could possibly do so, to avoid using it to any extent. At the suggestion of the board he had been occupied a greater part of the year in forming a syndicate which would provide, as mentioned in the report, for the lighting of the town of Wellington. It would take over the company's business in New Zealand, together with the benefit which they had in the contract for lighting. The syndicate had at last been formed, and £10,000 would be subscribed, of which the company would only risk £2,000 of their spare capital. He did not think it would be necessary for the company to find one shilling towards it, for he was of opinion that the shares would be applied for by residents in the colony. He hoped, therefore, when he met them again, they would not only be able to report the completion of the contracts, but the completion of the works, which will have been attained by the expenditure of this money, and the receipt of a revenue which would in itself enable them to declare a substantial dividend upon the whole of the capital of the company. There was another phase in the contract formed with the syndicate which was one of considerable advantage. If the company's goods continued to hold the position in New Zealand which they occupied now, the syndicate would become a very valuable customer, and they would gain directly and indirectly by the transaction. Another matter he referred to was the fact of the company contributing to the registration of the South Western District and Thames Valley Electricity Supply Company. In conjunction with powerful people they thought it would be well having regard to the tendency of the electric lighting business to run into central supply rather than into independent installations, to become interested in some district. While London was being portioned out among the great companies, they thought if the way was clear without any material expenditure it would be as well to get a company registered which would tend to secure the monopoly of the district. There was not, he was sorry to say, any net profit, but the gross manufacturing profits were £3,079 2s. 4d. Never since the company had been formed had they made one-third as much, and last year there was a loss of £1,417 6s. 6d., so that this business had improved during the year to the amount of about £4,500. The heavy interest on their mortgage debentures was the real reason they had been unable to declare a dividend; but for that they should have been able to declare a dividend of at least 3 per cent. Mr. Binswanger—one of their late directors—had retired; he had come on the board to represent some large debenture-holders, and since the bulk of the money had been paid off he had left it; while the directors had recently elected Mr. Hilton, a large shareholder, to assist them in the management of the company during the absence of himself, as he was going next week to visit New Zealand to see of he could obtain powers to light not only Wellington, but other towns in the colony. The chairman then went through the various items in the balance sheet *seriatim*. Referring to the paying off of debentures, and the raising of new share capital, he said that when they had applied for £25,000 new capital, the shareholders had come forward with only between £17,000 and £18,000. They had decided, then, not to stop half way, but to get their capital underwritten, paying 7½ per cent. interest. As to profit and loss, for the first time in the company's history this showed sales and receipts exceeding £20,000. They would remember that he had promised them that when their sales exceeded that amount the company would be able to declare a dividend, and he now ventured to say that his figures had been confirmed, for but for the interest on the debentures, they would have been able to declare a dividend of at least 3 per cent., and as the shareholders of the company held most of its debentures, they had received the money as interest, if not as dividend. There had recently been designed for them two very excellent little dynamos, suited to supplying houses requiring 20, 30, 40, or 50 lights, and not within the district of any supply company, as also a little motor, which might be worked from them, and which would do the work of a small gas engine. These had been advertised, and there was evidently going to be a considerable demand for them. Another branch of business that would become more important, in his opinion, than even their business in New Zealand, was that of electric welding. They had made a contract with the only people he knew who had been able hitherto to weld steel and cast iron with any success. They had already had the experiments carried on for nearly two years by customers of theirs, and one of their customers who had taken a plant costing some £1,100 or £1,200, and worked it for a year, had paid himself three times over. This was getting rumoured about, and he anticipated orders shortly from the large firms in the North of England. They had been lighting for the last two years the Spanish and French Exhibitions, and he had at last succeeded in securing the German Exhibition upon similar terms; he had also negotiated for the lighting of a Working Man's Exhibition, or rather of a Labour Exhibition, which was to be held in another part of London, so that, between lighting the Crystal Palace and these exhibitions, their name would come forward more and more every day.

Major Cotton, in criticising the accounts in a friendly spirit, said the underwriting of the capital was somewhat of a mistake, and he suggested, in case of anything going wrong, the directors would be personally responsible. He regretted that Mr. Binswanger had retired from the board, as he was a most practical man. The directors' fees, as now paid, were very large, considering the work done. They did not go down to the works, and only met once a month, and the fees of £250 each seemed rather excessive. When he was on the board the directors were paid £100. Referring to the New Zealand estimates, it was a dreadfully erroneous affair, and he thought the committee of works ought to have examined carefully the contracts.

After further discussion, a shareholder proposed the election of Major Cotton on the board, but this meeting with the opposition of the chairman, the matter was dropped.

Mr. De Castro and Mr. Hilton were re-elected directors, as also Mr. Russell Day, the auditor.

A vote of thanks to the board concluded the meeting.

Western Counties Telephone Company.

An extraordinary general meeting of the Western Counties and South Wales Telephone Company, Limited, was held last Friday at the Grand Hotel, Broad Street, Bristol, Mr. Charles Nash presiding. The Secretary (Mr. Henry F. Lewis) having read the notice convening the meeting,

The Chairman moved the adoption of the following:—

"That the directors be, and they are hereby, authorised by this general meeting to borrow any further sum or sums of money on such security (but not so as to prejudice existing debentures) and terms as to interest or otherwise as they may deem fit, and to secure the same by debentures upon the whole or any part of the property, funds, assets, or effects of the company, and so that any sum not exceeding £80,000, including the £50,000 previously authorised and issued, may be owing at one time, but so that the money to be borrowed under the authority of this resolution or consent shall not bear a higher rate than 6 per cent. per annum, nor (without the consent of the National Telephone Company, Limited), a higher rate than 5 per cent. per annum." He would say a very few words upon the progress of the company's business during the present year. The number of subscribers to the exchange and to the trunk lines in 1885 was 779, in 1887 it had increased to 2,034, and in November, 1890, it had increased to 3,540. As to receipts, after the payment of royalties, they had increased from £8,064 in 1886 to £21,286 in 1889, and judging from the progress made during the present year he had no doubt that the amount for 1890 would exceed £26,000. It was also satisfactory to find that the increase was going on at a more rapid ratio than it was last year. In 1889 the increase in the business was at the rate of £325 per month; during the present year the increase had been at the rate of £411 per month—so that the increase on that of last year had been at the rate of about £1,000 per annum. All that had required capital to be expended, and that was the reason of the proposal now to issue £30,000 on 5 per cent. debentures. He need not say much about that. They believed the security was an excellent one. The surplus remaining last year, after paying interest on existing debentures, was £6,848. The surplus this year would certainly be very much larger, and the interest upon the debentures now proposed to be issued would be only £1,500, so that it appeared to the directors that the security offered was a very excellent one.

Mr. Read seconded the motion. He remarked that the progress of the company's business was satisfactory to the shareholders in every sense.

In reply to a question as to the expiration of certain patent rights at a future period, it was stated that the company were covering their district so well that there would be little or no room for any competing company.

The motion was unanimously adopted.

Greenwood and Batley, Limited.—The directors have declared an interim dividend at the rate of 7 per cent. per annum on the preference shares; but have decided to postpone the consideration of a dividend on the ordinary shares until the end of the financial year.

The West Coast of America Telegraph Company.—The coupons due December 31st on the debentures of this company, will be paid by Messrs. Barclay and Co., Lombard Street. Coupons should be left three clear days for examination.

The West African Telegraph Company.—This company announces an interim dividend for the six months ended June 30th, of 4s. per share.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 12th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limi

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (December 11).	Closing Quotation. (December 18.)	Business done during week ending December 18, 1890. Highest.	Lowest.
250,000l	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101		
1,381,380l	Anglo-American Telegraph, Limited	Stock	48½— 49½	48½— 49½		
2,809,310l	Do. do. 6 p. c. Preferred	Stock	85½— 86½	84½— 85½	86¼	85⅝
2,809,310l	Do. do. Deferred	Stock	13¼— 13¾	13¼— 13¾		
130,000	Brazilian Submarine Telegraph, Limited	10	11¼— 11¾	11¼— 11¾		
84,500l	Do. do. 5 p. c. Bonds...	100	101 —103	101 —103	11½	11¼
75,000l	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	104 —108	104 —108		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1¼— 1¾	1¼— 1¾	$1\frac{11}{16}$	1⅝
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1½— 2	1½— 2		
$7,216,000	Commercial Cable, Capital Stock	$100	102 —104	104 —106	104½	104¼
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	$\frac{7}{16}$— $\frac{9}{16}$	$\frac{7}{16}$— $\frac{9}{16}$		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5¼— 5¾	5¼— 5¾		
16,000	Cuba Telegraph, Limited	10	11½— 12	11½— 12	11¾	11
6,000	Do. do. 10 p. c. Preference	10	17 — 18	17 — 18		
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼		
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10		
60,710	Direct United States Cable, Limited, 1877	20	10⅛— 10⅜	10⅛— 10⅜	10⅜	$10\frac{5}{16}$
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	13⅞— 14⅛	13⅞— 14⅛	$14\frac{3}{16}$	$13\frac{15}{16}$
70,000	Do. 6 p. c. Preference	10	14¾— 15¼	14¾— 15¼	15⅛	15
200,000l	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109		
1,200,000l	Do. 4 p. c. Mortgage Debenture Stock	Stock	104 —107	104 —107	105¼	...
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	13⅞— 14⅛	14 — 14¼	$14\frac{3}{16}$	14
320,000l	Do. 6 p. c. Debentures, repay. February, 1891	100	101 —103	101 —103		
91,800l	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049 3,976 to 4,326	100	102 —105	103 —106		
325,200l	Do. do. Bearer Nos. 1,050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105		
145,300l	Eastern and South African Tel., Ld., 5 p. c. Mort. Deb., 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	101 —104	102 —105	103¾	103½
198,200l	Do. do. do. to bearer, Nos. 2,344 to 5,500	100	101 —104	102 —105		
201,600l	Do. do. 4 p.c. Mort. Debs. Nos. 1 to 2,016... ...	100	... ...	100 —102	101¾	101¼
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7¾— 8¼	7 — 7½xd	7½	7⅛
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4¾— 5¼	4¾— 5¼		
70,000	Elmore's Patent Copper Depositing, Ltd., Nos. 1 to 70,000 ...	2	3½— 4	3½— 4	$3\frac{7}{16}$	3⅜
67,385	Elmore's Wire Mfg., Ld., Nos. 1 to 67,385, issued at 1 pm. all pd.	2	1¾— 2¼	1½— 2		
20,000	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£4 only paid)	5	2½— 3½	2½— 3½		
180,227	Globe Telegraph and Trust, Limited	10	8¾— 9	8¾— 9	9	$8\frac{13}{16}$
180,042	Do. do. 6 p. c. Preference	10	14½— 14¾	14½— 14¾	14⅝	14⅝
150,000	Great Northern Tel. Company of Copenhagen	10	15¾— 16¼	16 — 16½	16¼	...
15,000l	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	101 —104	101 —104		
230,000l	Do. do. do. (issue of 1883) ...	100	104 —107	104 —107		
9,384l	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11½— 12½	10½— 11½		
5,334l	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11½— 12½	11 — 12 xd		
41,800	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18½— 19½	18½— 19½	19	18
200,000l	Do. do. 4½ p. c. Deb., 1896...	100	100 —102	100 —102		
17,000	Indo-European Telegraph, Limited...	25	35 — 37	35 — 37	35½	...
11,334	International Okonite, Ltd, Ordinary Nos. 22,667 to 34,000 (£10 p.)	10	9½— 10	9½— 10	$9\frac{15}{16}$	9⅝
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9½— 10	9½— 10		
38,348	London Platino-Brazilian Telegraph, Limited	10	6 — 7	6 — 7		
100,000l	Do. do. do. 6 p. c. Debentures ...	100	106 —109	106 —109		
43,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 £8 pd.	10	7 — 7½	7½— 8	7¾	7¼
438,984	National Telephone, Limited, Nos. 1 to 438,984	5	4½— 4¾	4⅜— 4⅝xd	4⅝	4⅜
15,000	Do. 6 p. c. Cum. 1st Preference	10	12¼— 12¾	12 — 12½xd	12	...
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	9¾— 10¼	9¾— 10¼	12	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ⅜	⅛— ⅜	¼	...
9,000	Reuter's, Limited	8	8½— 9	8½— 9		
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ⅜	⅛— ⅜		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2½— 3	2½— 3		
3,381	Submarine Cables Trust	Cert.	108 —112	108 —112	109½	...
78,949	Swan United Electric Light, Limited ... (£3½ only paid)	5	4½— 5	4½— 5	4⅞	4¾
37,350	Telegraph Construction and Maintenance, Limited	12	43 — 45	43 — 45		
150,000l	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102		
58,000	United River Plate Telephone, Limited	5	3 — 4	3 — 4		
146,128l	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 95	90 — 95		
3,200l	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8½— 9½	8½— 9½		
290,900l	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101	98⅛	...
30,000	West Coast of America Telegraph, Limited	10	2 — 4	2 — 4	2⅞	2¾
150,000l	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	101 —106	100 —105		
64,174	Western and Brazilian Telegraph, Limited	15	10¾— 11¼	10¾— 11¼	11⅛	...
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6¼— 6¾	6¼— 6¾	$6\frac{9}{16}$	...
27,873	Do. do. do. 5 p. c. Deferred	7½	4½— 5	4½— 5		
200,000l	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106		
250,000l	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
88,321	West India and Panama Telegraph, Limited	10	2⅞— 3⅛	2⅞— 3⅛	3	$2\frac{15}{16}$
84,563	Do. do. do. 6 p. c. 1st Preference ...	10	11¼— 11¾	11¼— 11¾	11⅝	11¼
4,669	Do. do. do, 6 p. c. 2nd Preference ...	10	11 — 12	10½— 11½	11	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	120 —125	120 —125		
175,100l	Do. do. 6 p. c. Sterling Bonds	100	99 —103	99 —103		
42,853	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£3 only paid)	5	2¼— 2¾	2½ — 2¾		

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7⅛—7⅝.—Elmore Copper Depositing Priorities, 7 —7½.—Elmore's French Patent Copper Depositing shares of £2 (issued at 10s. premium, £1 10s. paid, including premium), 2⅜—2⅝.—House-to-House Company (£5 paid), 4¾—5¼.—London Electric Supply Corporation, Ordinary (£5 paid), 1⅝—1⅞.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), 1⅞—2⅛.—Preference, 4⅜—4⅝.

BANK RATE OF DISCOUNT.—5 per cent. (4th December 1890).

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers, December 11th, 1890.

CONTINUATION of discussion on "The Working Efficiency of Secondary Cells" and "Notes on the Chemistry of Secondary Cells," by Prof. W. E. AYRTON, C. G. LAMB, B.Sc., E. W. SMITH, and M. W. WOODS.

(*Authorised Abstract.*)

Mr. S. **JOYCE**, jun., said he had gained some experience with pasted cells when discharged at high rates, and therefore requiring frequent repairs. After several repastings he found it very difficult to make the red lead paste stick in the positive plates, and then tried litharge paste similar to that used for negatives. Cells so made had proved very satisfactory.

Mr. D. G. **FITZGERALD** enquired by what authority, and for what reasons, the authors called the peroxidised plate the positive, and the spongy lead plate the negative? He, himself, had good reason for reversing the designations, and in this he was following the example of Volta and Berzelius. Speaking of the chemical constitution of the negative (peroxide) plate, he said it was generally believed that $Pb\,O_2$ enters largely into its composition; there is, however, reason to doubt whether any of this compound is present, for the behaviour of the active substance on the plates is quite different from that of the pure peroxide of commerce. If a plate be made up of 80 per cent. of pure peroxide and 20 per cent. of the so-called peroxide produced by electrolysis, the E.M.F. falls when the electrolytic product is spent, and the subsequent action of the cell is unsatisfactory. In his analyses of the electrolytic peroxide he had always found some percentage of moisture present, even after it had been dried at a temperature above 212° F. He believes the chemical changes produced by electrolysis is represented by the equation $(Pb\,O_2)_{10}, (H_2\,O)_5, Pb\,SO_4 = (H_2\,Pb_2\,O_5)_5, Pb\,SO_4$, and that electrolytic peroxide is $H_2\,Pb_2\,O_5$. As regards the best kind of support or grid for the spongy lead, he said it was a mistake to use lead, for copper is in many cases much better. If the copper be left exposed local action takes place, but this is retarded by the addition of any alkaline sulphate. The beneficial effect of soda in secondary cells he attributed to the formation of a double salt which is easily reduced. Sulphate of magnesium has an extraordinary influence on lead plates, and by using a solution of it as electrolyte, he had got discharges 30 or 40 times greater than those obtainable from sulphuric acid. The strength of acid required attention when dealing with heavy discharges. Recently he had used acid having a maximum density 1·252, so that its specific resistance diminished as the cell discharged; in this way, and by the aid of copper supports for the spongy lead, he obtained a comparatively steady discharge of 2 ampères per pound gross weight of cell for 2 hours. With ordinary lead grids this would have been impossible.

Prof. **PERRY** asked the distinguished chemists present if the double sulphate really exists, and Prof. Ayrton inquired whether there were any simple tests by which such sulphates, if formed, could be detected.

Dr. **GLADSTONE** said Mr. Hibbert and himself had concluded that there was no evidence of double sulphates being formed in the action of secondary cells. He believed the general idea as to the influence of sodium sulphate was that lead sulphate was more soluble in the mixture than in simple acid; this, however, was not confirmed by experiment.

Mr. **CROOKES**, the new president, said sulphuric acid had a great tendency to form double salts, and thought it very probable that such salts would be formed in the case under discussion. Some results published by Dr. Gore in the *Phil. Magazine*, also point to the same conclusion.

Prof. S. P. **THOMPSON** was interested to learn that, like any other battery, the greatest action occurs at the upper parts of the plates. This might perhaps have been expected, because of its being the path of least resistance, but as the variation of the resistance of sulphuric acid with density is peculiar, and as the denser acid falls to the bottom, the action might have been modified thereby. The details relating to the formation of plates, given in the second paper, were, he thought, not new, and were practically what any one having a knowledge of the properties of the substances used and of the reactions which it was desired to bring about, would have arrived at theoretically. For example, to oxidise the positives one would aim at producing the most powerful oxidiser in the shape of ozone, the formation of which is facilitated by strong acid, large current density, and low temperature. On the other hand to reduce the litharge on the negatives it was known that a large current density mainly produces gas, and that reduction is best effected by small current density, at a fairly high temperature. Bearing in mind these opposite conditions one readily realises that the plates should be formed separately and that the negatives will require a much longer time. Several years ago he tried cells with electrolytes other than sulphuric acid and found that phosphoric acid was the only one which gave fairly good results. Speaking of pasted cells, Dr. **THOMPSON** inquired whether the authors had noticed that the oxidation of the positive paste begins near the grid, and gradually spreads through the mass of the plugs, and whether a useless nucleus remained unacted on in the centre of each.

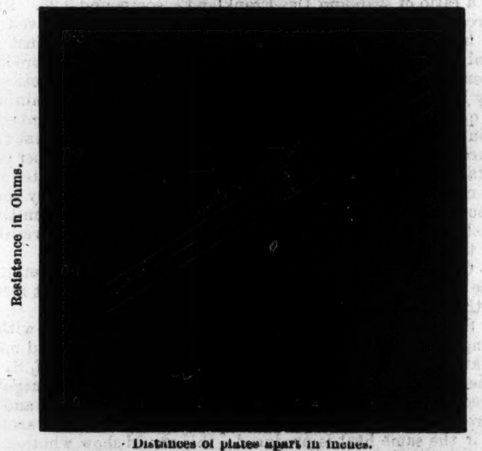
Replying to Prof. Thompson, Mr. E. A. **HALL** said he had made experiments on the capacity of cells with plates of different thickness, and found it independent of the thickness. This, he thought, tended to confirm Prof. Thompson's view as regards a useless nucleus. On the question of acid density he found that the capacity of a cell was increased 15 per cent. by using acid of specific gravity 1·15 instead of 1·20.

Mr. **PREECE** rose to correct an error made by Mr. Drake at the last meeting in stating that the density of acid in the P. and O. battery had been 1·40. Mr. Hall informed him (the speaker) that it had never exceeded 1·22.

Mr. T. **FRAZER** took exception to the remarks made by Mr. E. W. Smith, in his reply to the discussion at Edinburgh, with reference to the formulæ he (Mr. Frazer) had given for the resistance of cells for different currents, and for the fall of E.M.F. when the charging circuit is interrupted. In spite of what Mr. Smith said he maintained that his own statements were correct.

Prof. **AYRTON**, in replying, said the authors greatly appreciated the cordial reception given to the papers by practical engineers, for one of the aims of the Central Institution was to train students to do work and carry out investigations, the results of which would be of commercial value. Referring to Dr. Gladstone's criticism about the ammonium acetate method, he said that Mr. Robertson had used this method, but somehow or other the paragraph describing it had not been printed in the first proof. Speaking of measuring the resistances of cells, he pointed out that unless the curve connecting time and E.M.F. was discontinuous at the instant of breaking circuit, the method used should give correct results. So far as he knew there was no evidence of any such discontinuity. Mr. Crompton had said the resistance was practically independent of the distance of the plates apart, and that the sulphating of the negatives during rest depended greatly on light. Taking the case of resistance first, they had made experiments on a small two plate cell, and found that when the ordinary method of testing was employed Mr. Crompton's statement seemed nearly correct, but on using the more sensitive method illustrated in figs. 10 and 11 of the Edinburgh paper, this was not the case. Diagram A represents the results of these experiments. To investigate the effects of light, darkness, and sulphate of soda on the liberation of gas from idle negatives, they had experimented on three similar E.P.S. cells. The fully charged negatives, designated by A, B, and C, respectively, were put in three different vessels of acid, one of which contained 0·8 per cent. of sodium sulphate, and the gases collected. A powerful arc light illuminated one set of plates whilst the other were kept dark. Plate A, when illuminated, gave off gas very rapidly, whilst B and C in the dark produced very small quantities, which were about equal. On interchanging the plates, however, it was found that neither light or sodium sulphate had any marked effect on the rate at which gas was given off, for whether A was illuminated or kept dark, or put in ordinary acid, or in the sodium sulphate solution, gas was liberated rapidly at about the same rate, whilst B and C were equally inactive under all the conditions. They therefore conclude that the rate at which gas is liberated depends on some peculiarity of the plates themselves. Some speakers, he said, had remarked that many of the facts brought forward in the papers were previously known. To this he replied that none of the facts given as new were known to the authors before they discovered them experimentally. Manufacturers might have been aware of them, but if so, they had kept them secret and never published them. For example, Dr. Gladstone, one of the highest authorities on secondary cells, was not aware of the differences in the hardness of the plugs at different parts of the plates until the appearance of their paper. Another case in point was the fact that Dr. Thompson said there was nothing new in the methods of forming the plates, whereas Mr. King apparently did not know of them. Mr. Swinburne had also called their attention to a prediction of the cooling of cells during discharge made in 1887, but at that time he admitted that he had not observed it. Speaking of the efficiency of cells, he said some people think the very perfect testing apparatus gave the cells their high efficiency; this, of course, was not true, for their figures merely express the results obtained when cells are used in a proper manner. Referring to a criticism on the Edinburgh paper, which appeared in one of the leading technical papers of July 25th, he said the writer had

DIAGRAM A.



Resistances of small secondary cell. Plates 4½ inches × 2½ inches.

only partly understood the early part of the paper, for they (the authors) had there explained that one of the objects of the investigation was to see what error could be made by neglecting the previous history and the resuscitating power of cells. The same writer had also stated that the results of laboratory tests were not applicable to ordinary working conditions. Here, again, he had fallen into error, for a secondary cell is a thing complete in itself, and if two or three selected at random give good results under proper treatment, so any number if similarly treated will show equal efficiency.

Correction in previous abstract.—The third word from the end of last sentence but one of Mr. King's remarks should be "*circuit*" instead of "*surface.*"

Physical Society.—November 28th, 1890.

Prof. W. E. Ayrton, F.R.S., President, in the Chair.

The following communications were made :—

"Additional Notes on Secondary Batteries." By D. J. H. Gladstone, F.R.S., and Mr. W. Hibbert, F.I.C. After referring to the debateable points as to what compounds are formed and decomposed in the working of such batteries, the authors give the results of their examination of the red substance formed by the action of dilute sulphuric acid on minium, and which, Dr. Frankland believes to be a compound having the formula $Pb_3\ S_2\ O_{10}$. The ultimate analysis showed 72 per cent. of lead. A portion of the substance was treated with a 3 per cent. solution of ammonium acetate to dissolve out any normal sulphate that might be present; this left a residue much darker in colour than the original substance and containing 82 per cent. of lead. $Pb\ O_2$ contains 86·6 per cent. of lead. The colourless solution yielded a ratio of Pb to $S\ O_4$ varying from 2·0 to 2·15; pure $Pb\ S\ O_4$ requires a ratio of 2·16 and Dr. Frankland's compound 3·23. From these results the authors conclude that the portion dissolved was not a basic sulphate, and that the evidence tells against the original substance being a chemical compound. The authors have also continued their comparative experiments in the action of spongy lead on dilute sulphuric acid, either pure or containing a small quantity of sulphate of soda. After the experiments had gone on for five months, the residues were analysed; that from the pure acid showed 82 per cent. of lead sulphate and 18 per cent. of metallic lead, whilst that mixed with sodium sulphate gave 89 per cent. of lead sulphate and 11 per cent of lead. They therefore conclude that although the action of acid on lead is initially diminished by the presence of sodium sulphate, the final result is rather the other way.

Mr. G. H. Robertson, who had used ammonium acetate to analyse plugs from storage cells, said he had arrived at results much the same as those stated by the authors.

Mr. Swinburne said Dr. Frankland was absent, but without agreeing with him, he would suggest that Dr. Frankland might say that ammonium acetate decomposed the subsalt $Pb_3\ S_2\ O_{10}$, and then dissolved the sulphate $Pb\ S\ O_4$. The question might be attacked by acting on equal quantities of the substance, and the mixture $Pb\ O_2$, $Pb\ S\ O_4$, in a calorimeter with ammonium acetate, to see if the same heat is produced; this would show whether the substance is a mixture or a compound.

Dr. S. P. Thompson was glad that the authors allowed a possibility of basic sulphate being formed, for it is well known that an almost irreducible sulphate resulted from leaving a cell nearly discharged; this he thought would point to a possible formation of a basic sulphate from Pb O and $Pb\ S\ O_4$.

Mr. Swinburne did not see where the Pb O came from, except in newly pasted negatives, and he knew of no evidence of an intermediate stage of oxide on the plates. They appear to change directly to sulphate.

Dr. Thompson said that a rapid discharge was known to produce basic salts.

This, Mr. Swinburne thought due to deficiency of acid near the plates. Peroxide, he said, could not be formed on the negative without the acid was heterogeneous and gave rise to local currents.

Mr. W. Hibbert, referring to Mr. Swinburne's statement, said he had put one plate of spongy lead into strong acid and another into weak, and from this arrangement obtained a fairly large current. As regards the basic sulphate spoken of by Dr. Thompson, he did not think there was much probability of its being formed. Time, he said, had an important influence on a partially discharged cell, and he would not expect to easily reduce the $Pb\ SO_4$ formed by the long continued action of lead on sulphuric acid.

The President enquired whether Mr. Hibbert's argument would apply to a fully charged cell.

Mr. Hibbert, in reply, said that in this case the time required to produce sufficient snlphate to be irreducible would be very much longer, for in a partially discharged cell much sulphate was already formed.

Dr. Gladstone said he had anticipated that Dr. Frankland would raise the objection referred to by Mr. Swinburne. As far as he was aware there was no direct evidence either way, but he thought the suggested decomposition was improbable. If he acted on a mixture of $Pb\ O_2$ and $Pb\ SO_4$ he would expect to get the results actually obtained. Mixtures, however, were difficult to deal with, and the results not conclusive, for the physical condition of the mixture was not the same as that of the actual products. Referring to Dr. Thompson's remarks, he understood that it was the basic sulphate which he (Dr. Thompson) considered irreducible. Dr. Frankland, however, believed this sulphate more easily reduced than $Pb\ SO_4$.

The President remarked that he thought Dr. Frankland had two reasons for his belief in the existence of the basic sulphates. One of these was the difficulty in reducing normal sulphate, whilst the other was based on the rapid fall of E.M.F. at a certain part of the discharge. It was at this point that Dr. Frankland thought the new sulphate formed, and to meet this argument it was necessary to find some other explanation of the rapid fall. In this connection he (the President) enquired whether there was sufficient peroxide foımed on the negative plate to account for the drop.

On this point Dr. Gladstone could not speak decisively.

"An Illustration of Ewing's Theory of Magnetism," by Prof. S. P. Thompson, D.Sc. A number of small "charm" compasses were placed together on a glass plate of an ordinary vertical attachment to a lantern. A large magnet at a distance served to neutralise the earth's field, and a coil enabled a magnetising force to be applied in the plane of the needles. By this apparatus all the various phenomena exhibited by Ewing's model were beautifully shown on a screen. In the course of his experiments Dr. Thompson had found that when small magnets placed at moderate distances apart were used, it was much more necessary to neutralise the earth's field, in order that they might set themselves according to their mutual attractions, than when larger magnets were employed. A weak field directed the small openly spaced magnets, whereas with larger ones their mutual actions were much more powerful. This fact may, he thought, throw some light on the molecular groupings in magnetite (loadstone). This substance exists in two forms, viz., one crystalline, and the other of a heterogeneous structure. The former variety exhibits no magnetic retentiveness, whilst the latter is decidedly magnetic. As far as he was aware no sufficient explanation had been given of the non-retentiveness of the crystalline variety. A difference in the molecular distances, or groupings, might account for the peculiarity.

Mr. Boys said it was rather curious that Prof. Rücker had just devised a somewhat similar illustration of Ewing's theory, and he exhibited it at the meeting. It consists of little magnets made of long V-shaped pieces of watch spring pivotted by glass caps on needle points; the needle points are fixed in little discs of lead stuck on a sheet of glass which forms the base of a glass box. An open helix surrounding the box serves to apply magnetic force.

Mr. Swinburne called attention to two theoretical points. First as regards susceptibility (which he regarded as a mere ratio and not a property), he said that if particles of iron at a high temperature rotate, as has been supposed, the susceptibility should be negative, and Prof. Ewing had some reason to think that this was the case. The next point concerned the loss of energy when an armature rotates in a strong magnetic field; this, he said, was known to be considerable, whereas if Ewing's theory is correct, he would expect little or no loss, for all the little magnets would always put themselves in the direction of the field and would never pass through positions of unstable equilibrium.

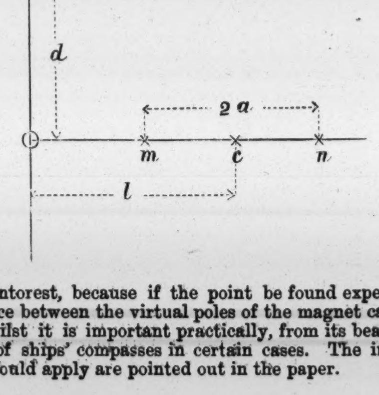
The President said he had discussed the question of negative susceptibility some years ago with Dr. Lodge with reference to the drop in the characteristics of dynamos, but he was not aware that any direct evidence had been obtained.

Prof. Perry thought negative susceptibility might be possible in strong fields but not in weak ones.

Mr. Swinburne, on the contrary, considered its existence would be more marked in weak fields.

Mr. H. Tomlinson said he had tried experimentally whether the susceptibility of nickel, when heated above its critical temperature, was negative, but he had not been able to detect it, although his apparatus was very sensitive.

"The Solution of a Geometrical Problem in Magnetism," by Thomas H. Blakesley, M.A. The problem referred to was the following :—Given the two poles of a magnet and a straight line intersecting at right angles, its axis produced, to determine at what point this line is parallel to the field. The question is of scientific intorest, because if the point be found experimentally, the distance between the virtual poles of the magnet can be determined, whilst it is important practically, from its bearing on the deviation of ships' compasses in certain cases. The instances in which it would apply are pointed out in the paper.



Assuming the points *m* and *n* (see fig.) to be the portions of the virtual poles and P the required point, it is shown that—

$$\frac{m}{(d^2 + m^2)^{\frac{3}{2}}} = \frac{n}{(d^2 + n^2)^{\frac{3}{2}}}$$

where $\text{O}m = m$, $\text{O}n = n$, and $\text{OP} = d$.

From this expression $\left(\frac{d^2}{2\,m\,n}\right)^3 - \frac{3}{4}\,\frac{d^2}{2\,m\,n} - \frac{1}{4}\,\frac{m^2 + n^2}{2\,m\,n} = 0$ is deduced.

Now in hyperbolic trigonometry we have a formula—

$$\cosh^3\theta - \tfrac{3}{4}\cosh\theta - \tfrac{1}{4}\cosh 3\,\theta = 0.$$

Hence, making $\frac{m^2 + n^2}{2\,m\,n} = \cosh 3\,\theta$ we have also $\frac{d^2}{2\,m\,n} = \cosh\theta$.

The value of θ can be then found by aid of the tables of hyperbolic sines and cosines compiled by the author and published recently by the Society. The distance, *d*, can thus be determined in terms of *m* and *n*.

A method of finding the point experimentally is then described, and the distance between the poles ($2a$) shown to be given by the expression $\frac{a}{l} = \tanh\frac{3\,\theta}{2}$ where $\frac{l}{d} = \sqrt{\frac{\cosh 3\,\theta + 1}{4\cosh\theta}}$, l being the distance O C. The latter function can be deduced from the tables already referred to.

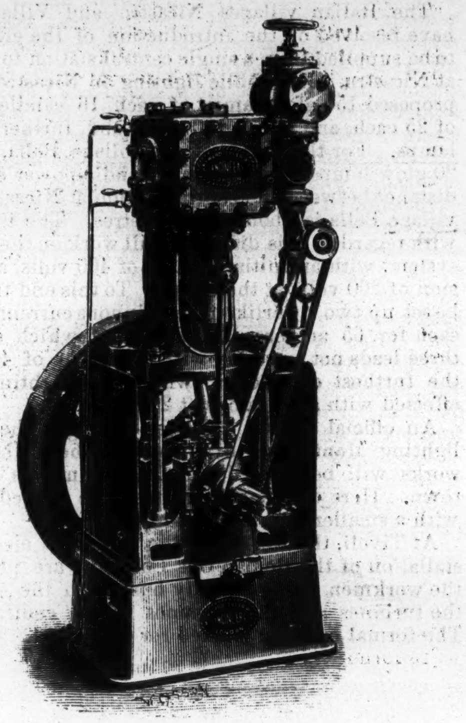
Experiment shows that the distance between the virtual poles soon approaches the length of the magnet, as *d* increases.

The strength of the field at P is given by the expression $\frac{4\,\text{M}}{d^3}\,\frac{\cosh^2\theta}{4\cosh^2\theta - 1}$ where M is the moment of the magnet. This can be simplified by arranging d and l so that $\cosh^2\theta = \frac{5}{4}$ and then becomes $\frac{5}{8}\,\frac{\text{M}}{d^3}$.

Under these conditions $\frac{l}{d} = \cdot 85065$ and therefore the angle O C P $= 40° - 23° - 10°$.

VERTICAL HIGH-SPEED ENGINE FOR ELECTRIC LIGHTING.

We give an illustration of a new vertical high-speed engine constructed by Messrs. Hayward Tyler & Co., of Whitecross Street. It is of the single-cylinder double-acting high-pressure non-condensing type. The general design is new, consisting of a strong cast iron bedplate having four mild steel vertical columns secured into suitable bosses. These columns carry a cast iron superstructure forming the guide bars, and a connection for the lower end of the steam cylinder. The bed-plate has the main bearings cast in one piece with it, and is provided at its lower edges with a capacious channel for catching waste oil. The cylinder is 7½ inches in diameter, and the piston has a stroke of 7 inches. The piston is of cast iron very deep, and fitted with Ramsbottom rings. The slides are of cast iron with ample surface. The valve is of a special double-ported type with short travel, and is connected to the valve rod by a circular gun-metal nut with a lock-nut and pin. The crosshead is fitted with square-bottomed gun-metal bearings, and a cap of steel forged solid with the guide slippers which are accurately turned and scraped to fit the guide bars. The connecting rod is of mild steel. The crosshead end is provided with a fork in which the steel crosshead pin is firmly shrunk. The lower end is of marine pattern with gun-metal bearings with flat backs, and having very ample surface. The crank shaft is of steel of double web type with large balance weights in one piece with the webs. The valve spindle is of steel of large diameter, forged solid with the guide, which latter is of extra size. The eccentric rod is of mild steel, with a bushed eye at the upper end, and a palm at the lower end for attachment to the eccentric strap. The eccentric is of cast iron, very wide, provided with a reversing plate, so that by simply changing a bolt the engine may be run either way. The eccentric strap is of best gun-metal of the stiffest shape and section, provided with steel bolts and extra deep nuts. The main bearings are of best gun-metal fitted into bored seats in the bed-plate, secured by driven gun-metal stop pins. The governor is of the high speed type acting directly on a double-beat perfect equilibrium throttle valve, and is so constructed as to have no joints. It is adjustable whilst running. A heavy turned and polished fly-wheel is securely keyed to the outer end of the crank shaft close to the main bearing. The diameter is 3 feet, width 5 inches. A strong cast iron base-plate carries the fly-wheel well clear of the floor line, faced on the upper surface, and provided with hand holes for bolts and a strong flange for securing to the foundation. Two lubricating boxes are fitted in suitable positions, so that by means of copper pipes the oil is carried to every bearing. Special means of carrying the oil from the lower ends of the pipes to the bearings are adopted, so that the whole can be oiled while in motion, and thus obtain constant running if necessary. Every part has been made strong enough for a steam pressure of 180 lbs. per square inch. The bearing surfaces throughout have been most carefully considered so as to secure perfect running. A speed of 350 revolutions per minute is about the best, but the engine will run without trouble at 450 if desired.



COMMUNICATIONS FROM ITALY.

[FROM A CORRESPONDENT.]

The alternating current central station erected at Venice by the Edison Company of Milan has, in consequence of the still growing demand for the electric light, been again enlarged by the addition of a fourth alternating current machine for 80,000 watts and the accompanying transformers. The electrical works at Venice are thus raised to the total capacity of 320,000 watts.

The same company is at present erecting at Intra an extensive electrical works on behalf of a local manufacturer named Sutermeister.

A large water-power is to be utilised by the transformation of its energy into electricity in order to supply electric light and motive power to the establishments in the valley. This installation presents an especial interest, since alternating currents are to be used both for lighting and for the transfer and distribution of power. Consequently the electric installation of Sutermeister at Intra will be the first in which the alternating current will be used on an extensive scale for the transfer and distribution of power. The electric works are in the first place to comprise four turbines, of 150 H.P. each, and as many alternating current machines with the accessory exciters and accompanying apparatus, and they are now being begun with the erection of two turbines and dynamos.

The Italian villages Nicastro and Villaggio Bella have resolved on the introduction of the electric light to be supplied from a single central station to be erected at Nicastro. For public lighting in Nicastro, there are proposed 150 glow lamps of each 16 candle-power, 40 of 25 each, and 10 of 100 each, and, further, three arc lamps. For the streets of the village Bella, altogether 20 glow lamps of 16 normal candle-power each. The distance between the central station at Nicastro and the village Bella is about 1,300 metres. The installation, with regard to this distance, will work on the three-lead system, with an initial tension of 400 volts, and a tension of 200 volts at the lamps. To this end there are to be set up two "Oerlikon" continuous current dynamos, each for 65 ampères and 200 volts, which supply the three leads not in series with a current of 400 volts at the furthest conductors, whilst the lighting will be effected with glow lamps at 200 volts.

An official decree has been taken as the basis for lighting Monteleone di Calabria, where the electric works will be erected about 1,200 metres from the town. Here one place only has to be lighted, and that with a smaller number of lamps.

At Tivoli, the works for the extensive electrical installation of the Roman Gas Company are progressing, the workmen being already busy with the erection of the turbines and the dynamos in the central station. The formal opening is fixed for May, 1891.

LIGHTING OF A POWDER MILL.

A RECENT issue of the *Bulletin International de l'Electricité* contains a description of the electric lighting of the National Powder Mill of St. Médard-en-Jalle. The directors had erected a small experimental plant at first, in order to test the applicability of the electric light throughout the works. The lighting being found satisfactory, MM. Sautter, Harlé & Cie., were instructed to put up a complete installation, which is now in full operation. There are installed nine arc lamps of 1,500 C.P., and a number of incandescent lamps, which are protected against breakage by glass globes and wire guards. Owing to the various buildings being some distance from each other, it was not easy to carry out the lighting arrangements. It was necessary to instal glow-lamps in buildings 975 yards from the generating station, and to maintain a constant potential of 110 volts at the end of a conductor of 45 mm. square section, whilst the consumption of current might vary from zero to 120 ampères. These objects have been attained by the employment of an extra compound-wound dynamo having two windings. One of these is in series and the other in shunt, and separately excited at a constant potential by an independent dynamo. The working of this machine has answered the anticipations put forward. When fully loaded, the loss in voltage at the distributing centre does not exceed 6 volts, and the independence of the arcs has been obtained. Two relays, one having a green and the other a red lamp, are placed in the engine room, so that any variations in the E.M.F. due to any change in the speed of the exciter may be ascertained. The dynamo, which runs at 800 revolutions, works 18 hours out of the 24 with a variable load.

CORRESPONDENCE.

Underground Cables.

Your issue of the 5th inst. contained a letter from Mr. C. H. Yeaman, to which was appended a communication from the Liverpool agent of the India-rubber, Gutta-Percha and Telegraph Works Company, of Silvertown, written under the direction of the London house, and containing two statements which are inaccurate and misleading, and which are liable, if uncontradicted, to injure our business. The statements are as follows :—

(1) "At West Brompton the Fowler-Waring cables on trial there have been abandoned, and our vulcanised rubber cables are exclusively used."

(2) "We believe the Fowler-Waring cables have been condemned ; the reason Mr. Ferranti did not order the 10,000 volt cable from us is that he did not consider that they were within the bounds of possibility, commercially."

In reply to the first of these statements, the cables supplied to our company to the House-to-House Company at West Brompton have not been abandoned, but their use has been postponed owing to the difficulty of making two T joints on heavy lead-covered cables in a joint box $3\frac{7}{8}$ inches × $3\frac{7}{8}$ inches × 10 inches.

This difficulty is a serious one, but, I believe, we shall completely overcome it. Mr. Hall, the manager of the West Brompton Company, authorises me to add that the cables supplied by us, when tested in water, gave a higher insulation resistance than any of the cables supplied by the Silvertown Company ; he assures me that only the difficulty I have referred to has prevented the extensive adoption of our cables.

In answer to the second statement, it is untrue that the cables we have supplied to Mr. Ferranti have been condemned ; but as I understand Mr. Ferranti himself will deal with some of the other statements in this misdirected canvasser's epistle, I am content to leave any further remarks on this subject to him.

It is only due to the Silvertown Company to observe that they leave to agents the ungracious task of propagating inaccuracies and misrepresentations intended to injure their rivals.

Alfred E. Mavor, *General Manager.*
For the FOWLER-WARING CABLE COMPANY, LIMITED.

9th December, 1890.

In your issue of November 21st you publish a most interesting paper by Mr. C. H. Yeaman, "On Lighting from Central Stations. You also publish in your issue of December 5th a letter written to Mr. Yeaman by the Silvertown Company. In both of these publications my name is mentioned, and facts are not stated as correctly as I should have liked to have seen them.

To begin with, I may say that the amount of "wild talk" about 10,000 volts is quite unwarranted, especially as the people who speak about it have, practically, no knowledge on the subject. 10,000 volts, although it can be worked, and machinery and cables made to stand it, is not a thing which at the present moment is as easily dealt with as some people may imagine. Moreover, I may say that a cable which has to be used for a daily supply of 10,000 volts must be able to stand a very prolonged test of 25,000 volts at least with a considerable horse-power at the back of it.

Now, as regards the statement as to the abandonment of the Fowler-Waring cable by the London Electric Supply Corporation, Limited, I may say that this is quite incorrect. The only trouble that there has been with the Fowler-Waring cables has been in what they have been called, not in the cables themselves. They were, and are first class cables for the purpose for which we are using them, viz., the supply of current at 2,500 volts. If the cables were required for a higher pressure they would have to be more heavily insulated, and this no doubt can easily be understood.

I may also add that our permanent distributing work is being done with insulators other than India-rubber, and that I do not propose to use India-rubber where I wish to have a lasting permanency.

S. Z. de Ferranti.

December 11*th*, 1890.

Improvements in Telephone Switchboards.

I should be glad if you could find room for a further letter on this interesting subject in reply to that of Mr. H. F. Jackson in last week's REVIEW.

In criticising my criticisms your correspondents have introduced arguments tending to show how the "improved" board would work if it had some other attachments than it has, or were in fact some other kind of board than it is; and Mr. H. F. Jackson refers to the single-cord *system*. The single-cord system is, telephonically, of remote antiquity, and it has been developed to a point of speed and easy manipulation which your correspondents do not apparently appreciate. But, so far as my information goes, those who have developed it and are fully cognisant of all its advantages, do not recommend its adoption for small exchanges. I have taken great care to prevent the assumption that the single-cord system was at all involved in the discussion, and the words "single-cord board" in this letter will be understood to refer only to the one of which a description was published in your columns on October 24th. I can now go back to the original questions raised by that description, viz., whether the single-cord board is superior in operating to a double-cord board with speaking keys, and which of the two is the more suitable for adoption in small exchanges.

In my article I referred to advocates whose opinions were entitled to respect. Mr. Jackson is clearly one of those. It is satisfactory that his opinions, and the grounds for them, have found expression.

I agree fully with Mr. Jackson in the two points to be aimed at. The first point is met exactly by the double-cord board; much depends upon the way in which the second is interpreted; and I would add a third to cover facilities for extension.

In regard to 1 (*a*): The insertion and removal of a plug count two for both boards. Any other value may be given them, but it must be on both sides of the account. That it may be seen my comparison was not unfair, I will examine Mr. Jackson's reasons for a reduction: It is because the first three movements are made with the same plug. There is a conversation between one and two. Frequently there will be ringing as well. Movements two and three are more nearly related, but are no quicker than plug movements, counting two on the double-cord board. There is no advantage by reason of the movements being made with one plug. There is a disadvantage which I will show later.

I have no difficulty in giving my reasons for asserting that the double-cord movements are done more quickly, and I think it will be seen that in practice it must be so. The time occupied in any operation depends on the mechanical work to be done, and the mental effort required to do it. There are seven plug movements, against five plug and two speaking key movements. If halves should come in anywhere, it should be on account of the speaking keys, but I have not claimed them. I prefer to leave it to any telephonic reader to estimate the value for himself. All the seven plug movements are slower by reason of the area to be covered, and one of them involves the selection of *some one* out of, say, a hundred, instead of *any one* (the nearest at hand) out of twenty or less. On the double-cord board, the only selection necessary is the second plug, to which the hand of the operator is guided by the cord of the first. Reply to 1 (*b*) is included in my second paragraph.

2. Simplicity of circuits. Mr. Jackson has overlooked a second contact on the engaged line of the single-cord board. It is in the unused spring jack. This narrows the question down to a simple one—the speaking-key contacts on an engaged line. It seems now that the only benefit conferred by the single-cord board is the absence of these two contacts.

Of course every contact is a *possible* source of trouble. On a well-designed switchboard every contact is also an aid to better working. "Troubles" of one kind may be largely avoided by a little trouble of another kind. In this respect let me compare the contacts on the two boards for the same number of subscribers. On the single-cord key-board there are 100 loose contacts open to dust and falling particles, on the double-cord key-board there are 80 spring-platinum point contacts protected from falling particles and so disposed that faults from "floating" dust are reduced to a minimum.

As a matter of fact, the trouble caused by keys is infinitesimal, whilst the advantages they confer are considerable. Their utility may be illustrated by reference to the diagram and description (October 24th), where there are none. The freedom from contacts is obtained at considerable cost. As speaking keys are so many branch lines by which the operator's outfit may be diverted easily and quickly to any circuit, an operator by their aid is able to "overtake her work." When there is only one means of access to the operator's instruments, as in the case of the single-cord board there are no such facilities, and she is consequently more "tied up," and putting through a number of subscribers in succession is a slower and more laborious process. Tapping a line in the one case is easy; in the other, difficult.

The "trouble" argument applies as much (perhaps more) to the cords. Mr. Jackson says that speaking keys might have been fitted. But surely if the argument is worth anything at all, it is an argument against the needless multiplication of either keys or cords. On a double-cord board the cords, and all the apparatus in their circuit, are auxiliaries only. In the single-cord board the cord is a link in the main line. It is, together with its contact, a weak link, and if it should be a broken link, the line is entirely disabled. This is bad for small exchanges, and especially bad in the case of small boards under private control. On the double-cord board a fault on cord, plug, or key does not interrupt a circuit. The afflicted set is placed *hors de combat* until it is convenient to repair it.

The greatest failing of the board to which I have drawn attention is confirmed in Mr. Jackson's letter, wherein he states that it is not usual to place two boards side by side, but to remove one board, and replace it by another as the subscribers increase. I will here define the third point which I suggested above. It is:—

(3) A switchboard with which an exchange is started should not need to be removed, but should be capable of being added to by other boards of the same kind until the exchange attains multiple rank.

Reasons which will justify changes and removals will occur to any exchange manager, but there are no reasons sufficiently good to establish, as a practice, such an unsound principle as removals with every increase of 20 or 50 subscribers. But for this correspondence I should have to apologise for expressing so well recognised a rule.

Mr. Jackson says it would be impossible to work 500 subscribers in a space of 10 feet. I enclose for your inspection a photograph of an exchange with ten 100-line boards. These boards are not 23 inches, but 17½ inches wide (the 23-inch board is a concession to appearances). I shall be glad to show the photograph, and give the name of the exchange to Mr. Jackson or anyone interested. This is an exceptional instance, but it goes to prove that the third point is not only theoretically safe, but practically attainable. The size of board to be adopted will vary considerably; 25 is a safe minimum and 100 a safe maximum, according to the varied circumstances which exchange managers have to consider.

In reference to the question of accessibility raised again in Mr. Jackson's postscript; the accessibility of the single cord board is nearly as good as the double for the same things. The reason why all the working parts can be reached from the back is, because there are no working parts anywhere else, and, as I have had to point out, it suffers in consequence. There are two accessibilities—one an operator's the other a mechanic's. If they do not happen to run together, it is so much the worse for the mechanic.

In reviewing the matter as impartially as one who has taken an active part in it can, I find that the numerous advantages claimed on October 24th are reduced to the two contact points. This advantage may be expressed by another point—a mathematical one. It has no magnitude.

Every switchboard is a combination of advantages and disadvantages which have to be carefully weighed. In the case of the double-cord board this has been done, with the result that probably nineteen-twentieths of the telephone world have adopted it for small exchanges. In the case of the single-cord board the balance may be easily struck, if the mathematical point be weighed against the very considerable disadvantages which have come out in the course of comparisons which I did not begin, but which I could easily continue in much greater detail.

J. E Kingsbury.

December 16*th*, 1890.

Electric Light on Shipboard.

In my former letter on this subject a mistake occurred, which you pointed out by an asterisk and a foot note; the word should have been (*single wired*).

In regard to Mr. A. Campbell Swinton's remarks on my assertion regarding lead-covered wires, I may be permitted to explain that I treat the question of wires and their coverings from a rather different point of view than that taken by Mr. Swinton.

That the British Admiralty and others use lead-covered wire, and find it good enough for their purpose, is no proof, to my mind, that it is the best wire for ship lighting purposes.

Mr. Campbell Swinton, and those others who use lead-covered wires, admit that the lead acts simply as a waterproof covering; his letter amply proves, this; it also admitted that the lead is not to be relied on for mechanical protection. Now I think a simple cable, having a continuous vulcanised rubber insulation, with a good braiding, comes quite up to the lead-covered cable, in so far as its being waterproof, and it does not require any more protection than the lead-covered wire. The question is this, whether is lead-covering or vulcanised rubber preferable as the waterproof in a cable for ship lighting? The lead covering is not an insulation; its object is to protect the insulation from water. The vulcanised rubber is the insulator in a cable, and can protect itself from water.

It is very well to get a cable from a maker guaranteed 500 megohms per mile, but after that you take, say, a hundred yards of it, cut the insulation away at a dozen places, make a joint at each, and cover them up again, soak it then for a week or two in sea water, joints and all, and then test the insulation. If the work is done by skill and with care, I admit that both lead and vulcanised cables will stand this test; but the tests would seem to make out that the lead covering is superfluous, seeing the vulcanised rubber can dispense with it, and the cost of making the lead joints is something extra.

I do not condemn lead-covered cables by any means. I think there can be nothing better for some purposes, and would use nothing else for long stretches of cables in tunnels, conduits, or underground work, where the covering does not require to be broken in many places, and joints are few and far between.

But in ship lighting, the unbroken lengths are short and the joints are many. Under these circumstances, my own experience is that a good vulcanised insulation, run in wood casings in the passages, saloons, and berths, and in galvanised iron wire sheathing in the engine rooms, boiler stoke-holes, and shaft tunnels, and to the signal lights, is the best that can be done on shipboard, and so that the wire may be as short as possible, and the joints as few as possible, I prefer single wiring

Rankin Kennedy.

The Electro-Deposition of Copper.

Most of your readers will perceive, without any tedious elucidation on my part, how strangely Mr. W. Stepney Rawson misapprehends the drift of my letter. Because I say that, in considering a given case of electro-deposition from a general and abstract point of view (with the object of determining the expenditure of energy under any assumed conditions relative to *time* and *tank resistance*), we are bound to take the expression for energy $\mathrm{C\,E}\,\theta$, rather than the equivalent expression $\frac{\mathrm{C}}{n} . \mathrm{E}\, n . \theta$ (with a concrete value for the number, n, of tanks in series), he arrives at the conclusion that I am endeavouring to "justify the employment of a parallel system of electro-deposition." It is obvious from what I stated that, in regard to the arrangement of tanks in parallel or in series, there is no advantage apparent one way or the other until we come to practical considerations of convenience, &c., which may justify us in giving a concrete value to n.

In regard to Mr. Rawson's question, intended as a *reductio ad absurdum*, I am no authority in dynamo machines, but I think I may say that no large machines have as yet been constructed with so low a terminal P.D. as 1 volt. I have, however, some recollection of a machine by Siemens and Halske giving 1,000 ampères under a P.D. of 3·5 volts; and if a machine giving 3,500 ampères at 1 volt were really required (which it is not), I have no doubt but that it would soon be forthcoming. With $n = 1$, nearly the required quantity of work could be done with 21 such machines, or with a proportionately smaller number of machines of greater power.

Since I started the old *Electrician*, more than a quarter of a century ago, I have had much to answer for in the way of "leading articles;" and this may perhaps in some measure account for a tendency to use the editorial "we" in place of the egotistical pronoun. But I really must deny Mr. Rawson's soft impeachment in regard to this paper, for the simple reason that I have never written for it excepting over or under my own name. I am under the impression, moreover, that the editorial columns are entirely monopolised by the editors themselves. Although I consider Mr. Rawson's suggestion to be "rather bad form," I am personally not at all offended by it. But why, if things were otherwise than they are, should I not write even editorially for the REVIEW, provided I could get the Editors to accept my "copy?" Would Mr. Rawson suggest that I am not a fit and proper person, that I have interested motives, that I am biassed against himself, or the process in which he is interested? If so, I can only say that (having a few years ago spent a few pleasant hours in Mr. Rawson's company), any bias on my part would be in his favour, and that I have no interest whatever in depreciating any process for the electro-deposition of copper. Mr. Rawson, who seems to write with some bitterness, has apparently not noticed that we both, in my estimation, carried a point against the Editors in the matter of the number of working hours per week, and that my opinion as to current density allowable is decidedly favourable to the process above-mentioned.

Desmond G. FitzGerald.

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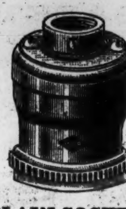

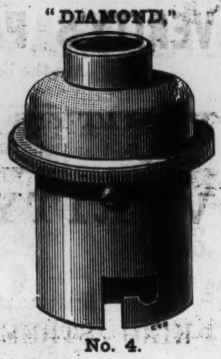

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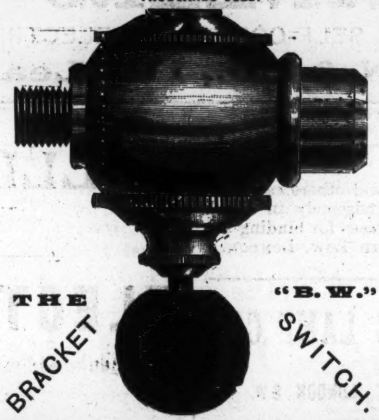

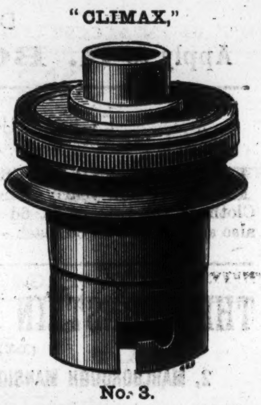

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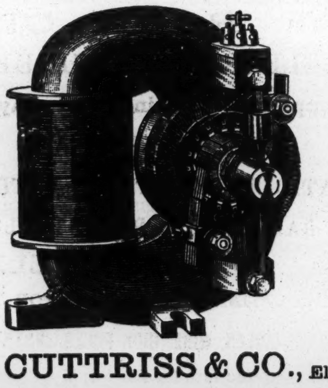

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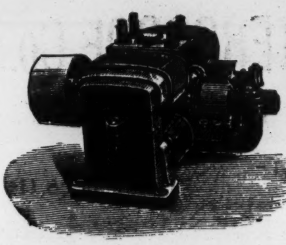

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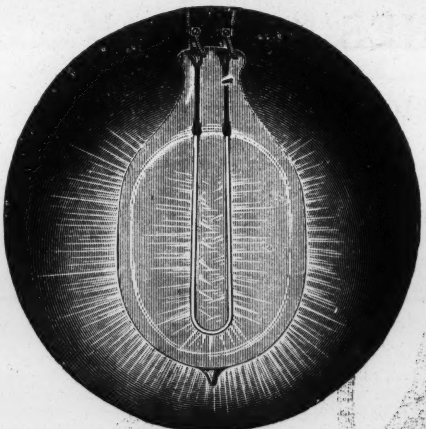

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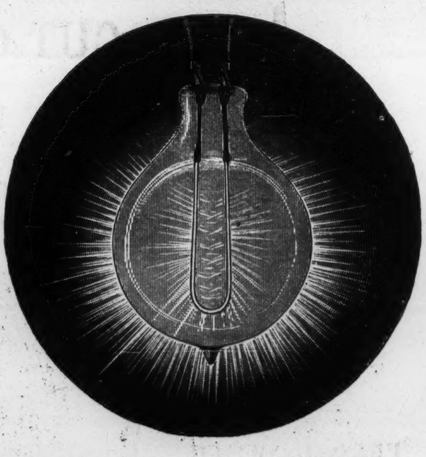

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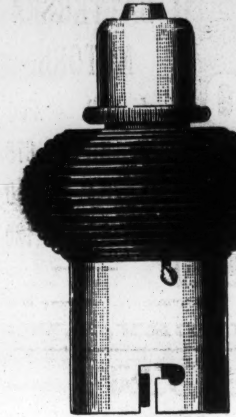

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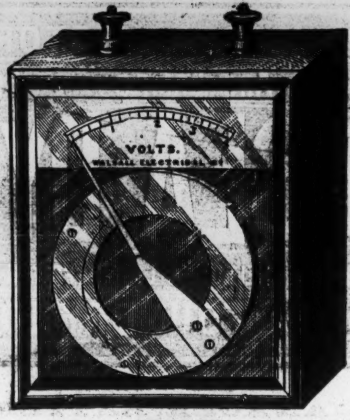

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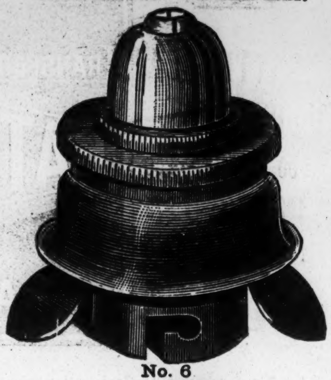

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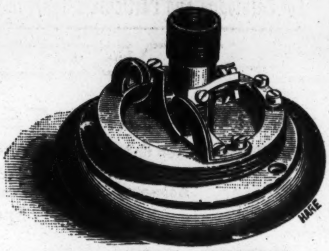

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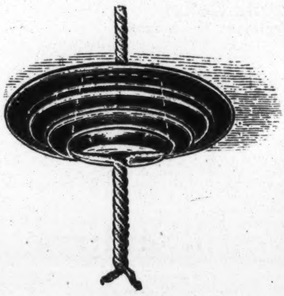

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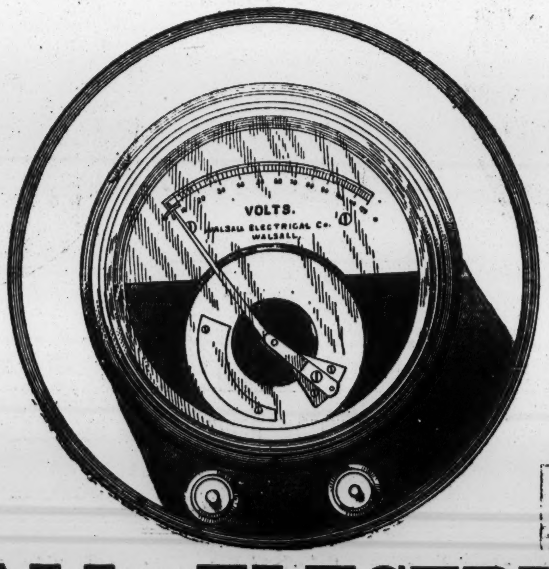

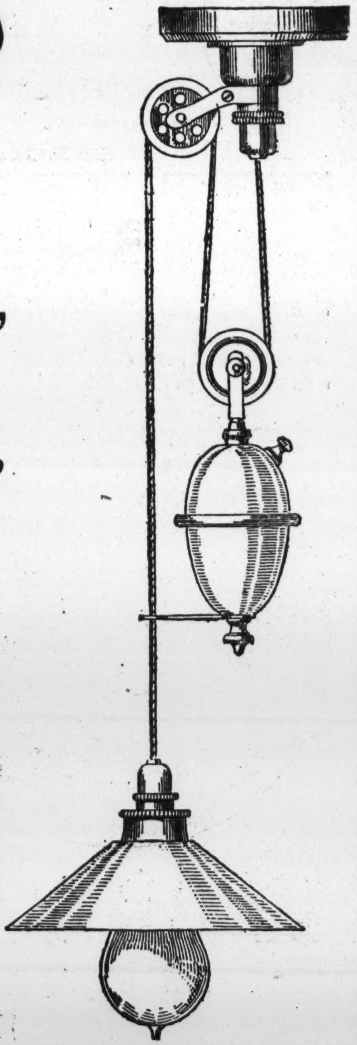

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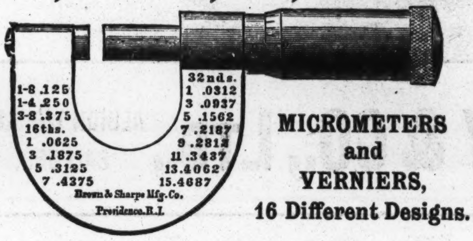

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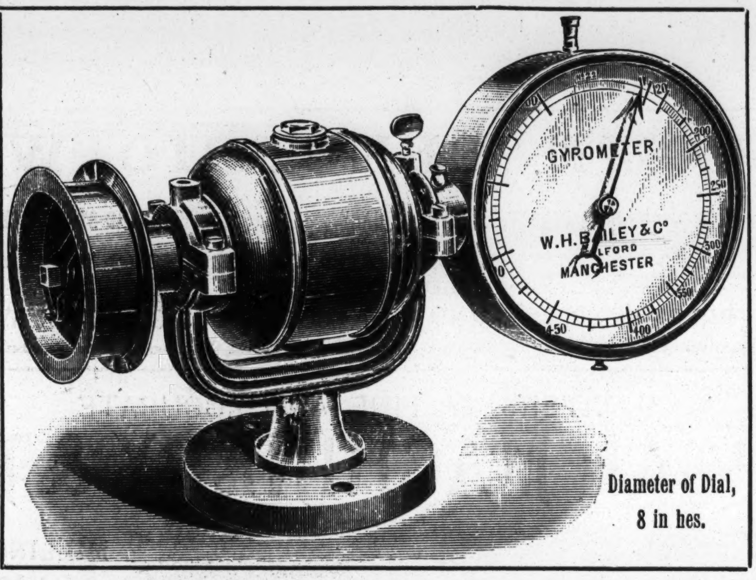

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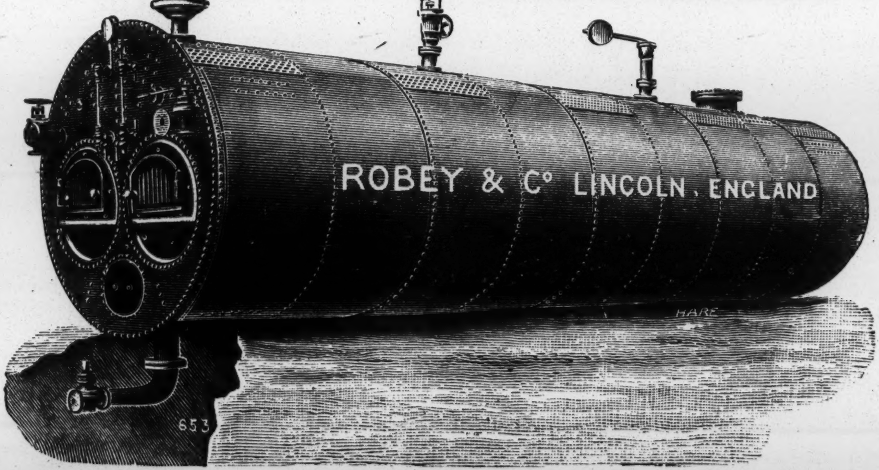

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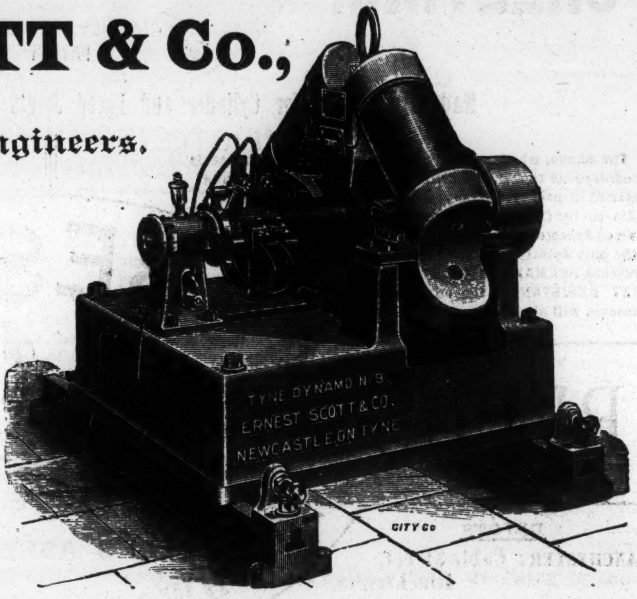

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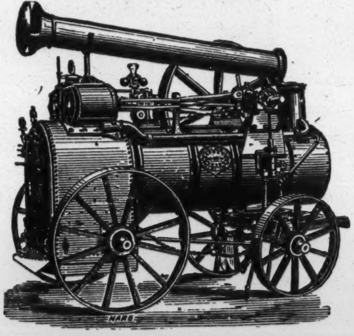

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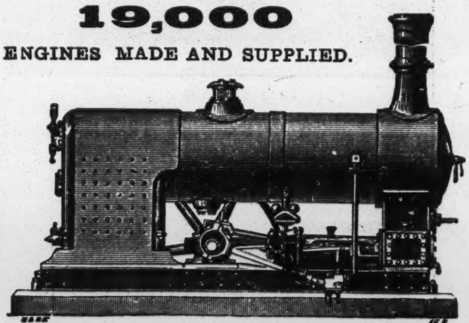

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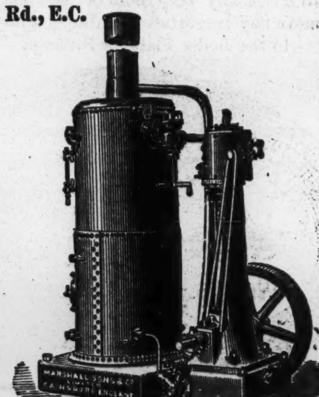

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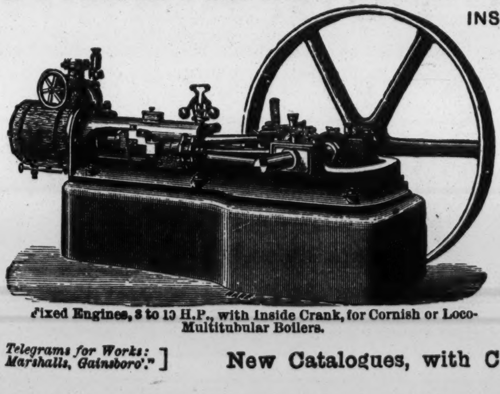

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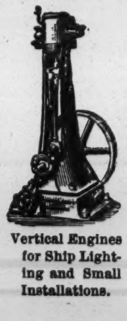

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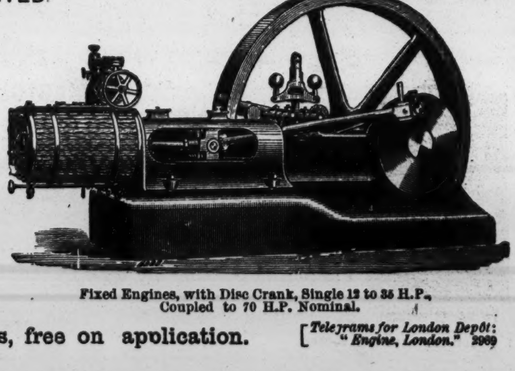

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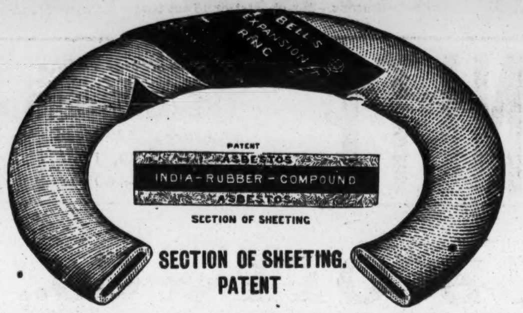

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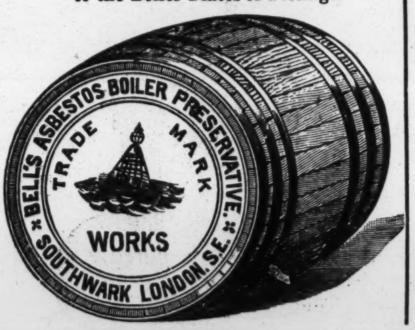
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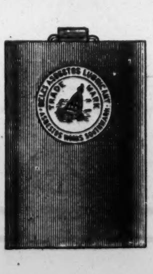

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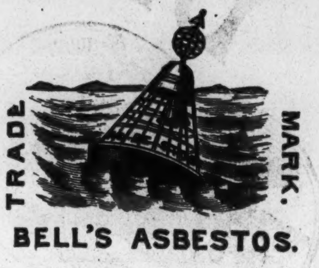

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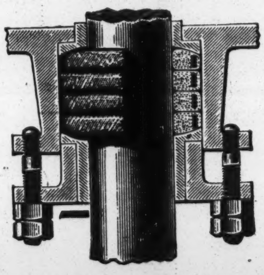

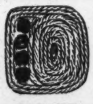

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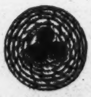

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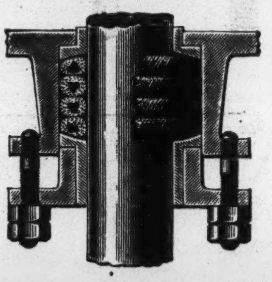

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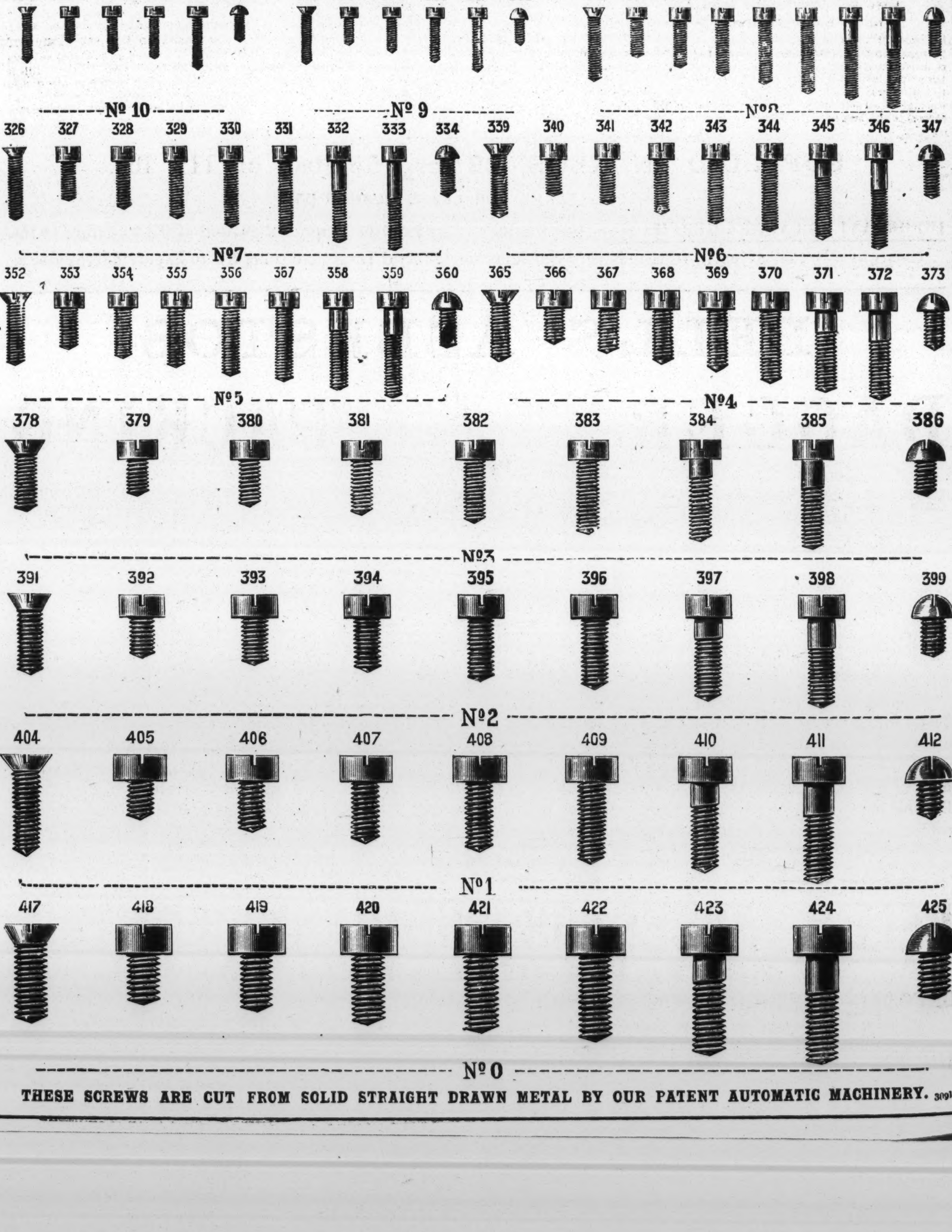

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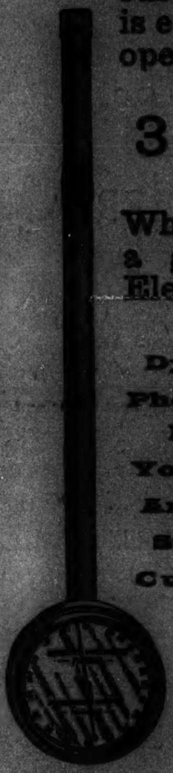

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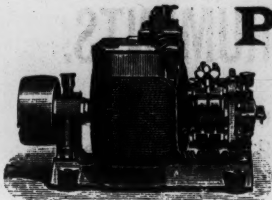

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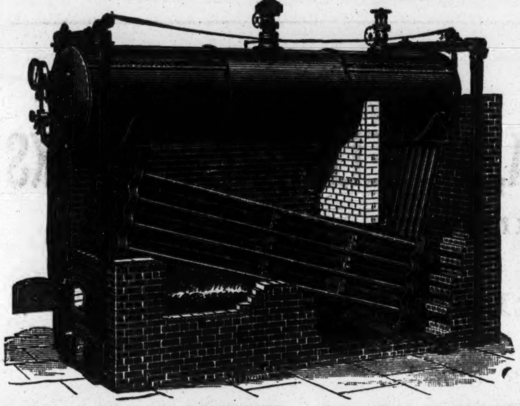

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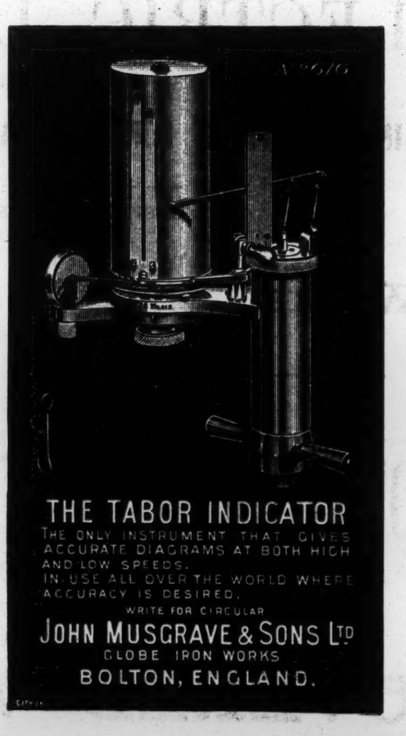

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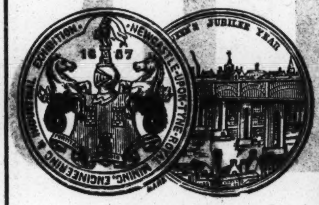

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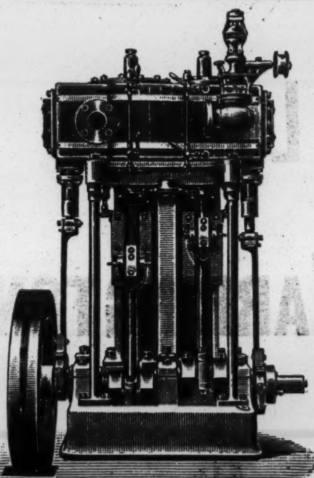

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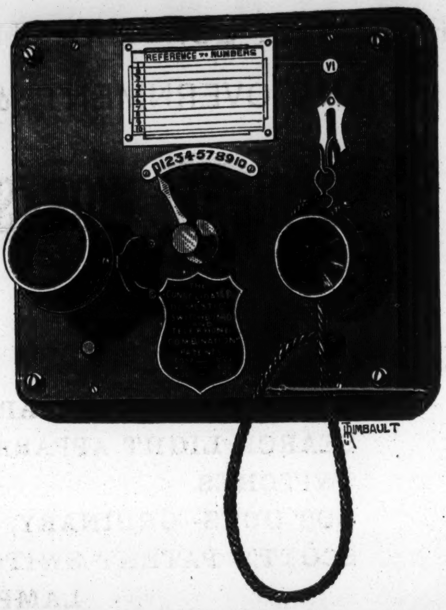

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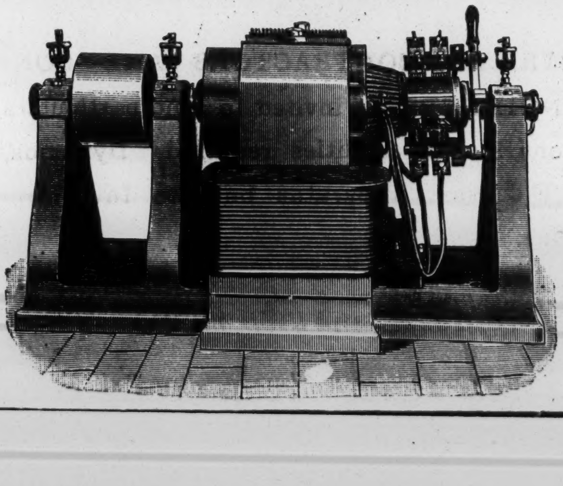

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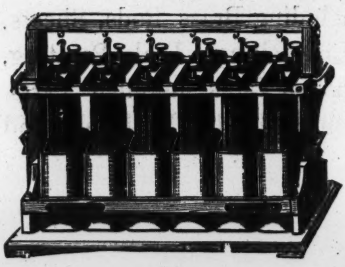

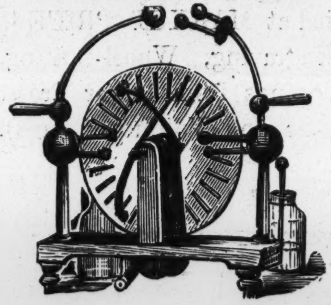

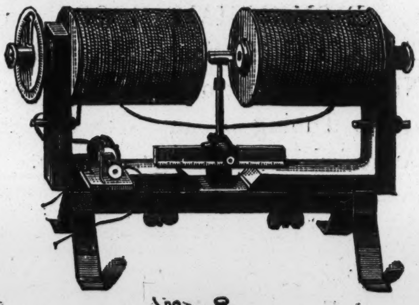

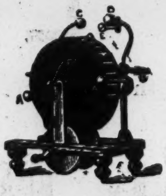

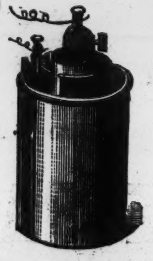

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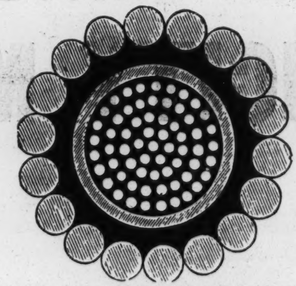

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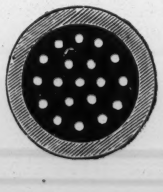

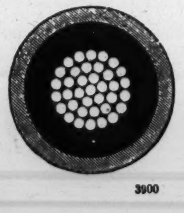

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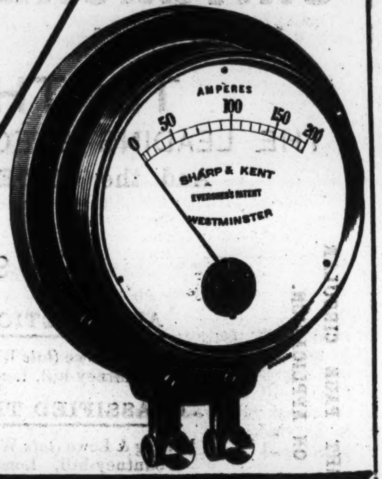

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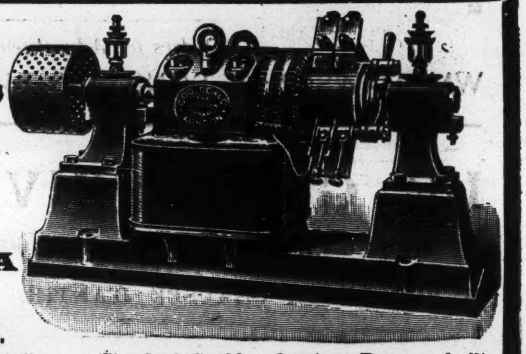

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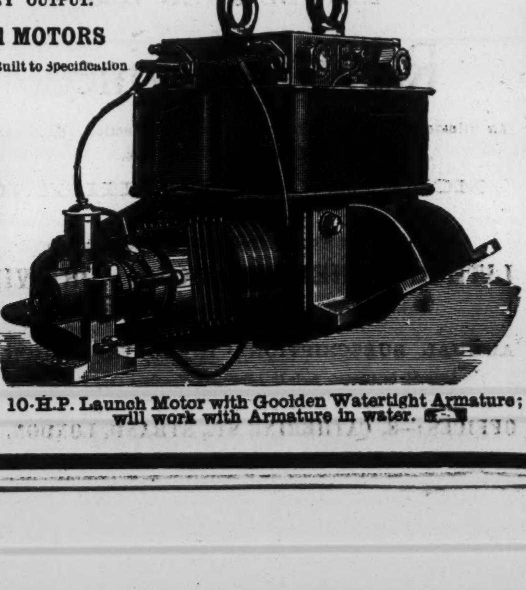

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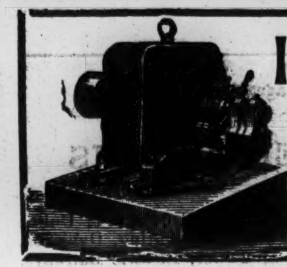

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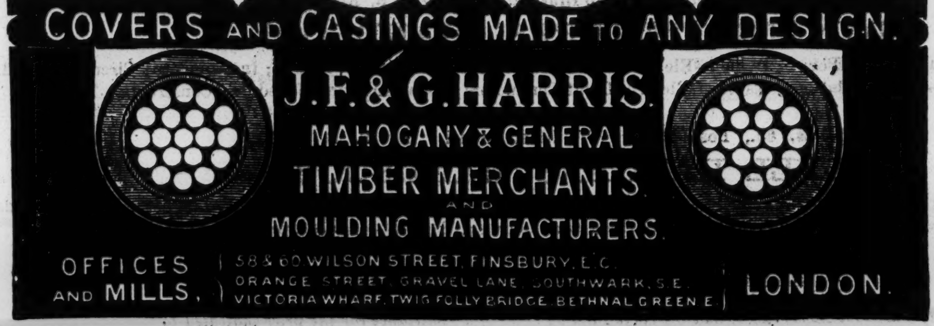

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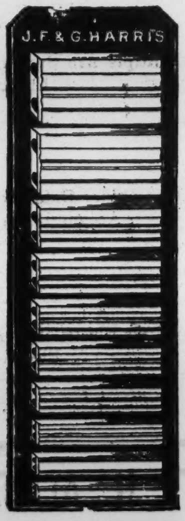

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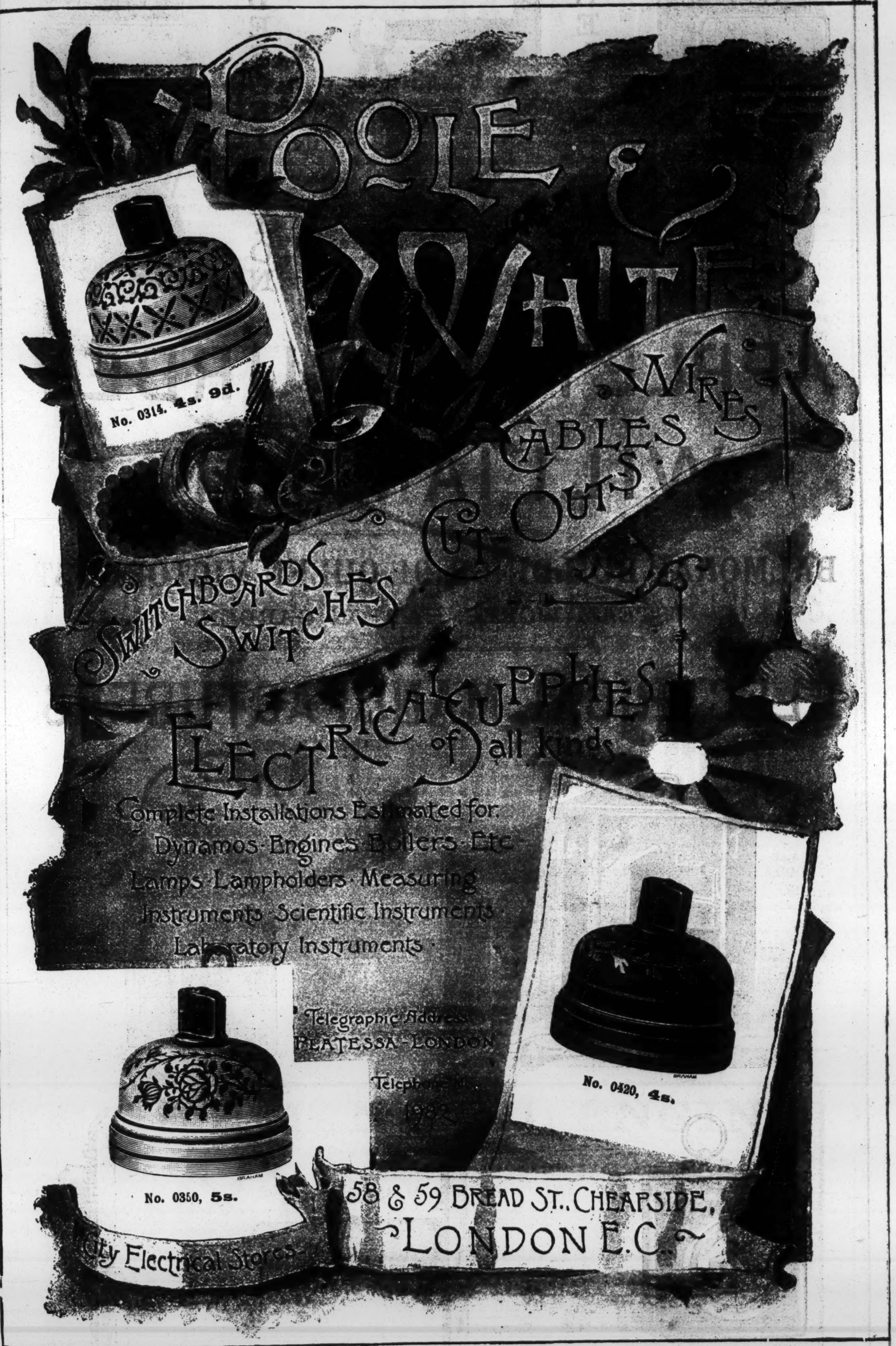

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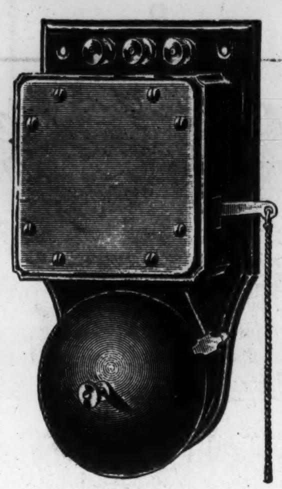

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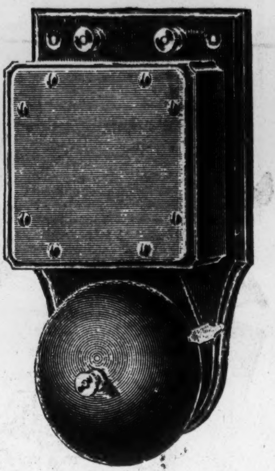

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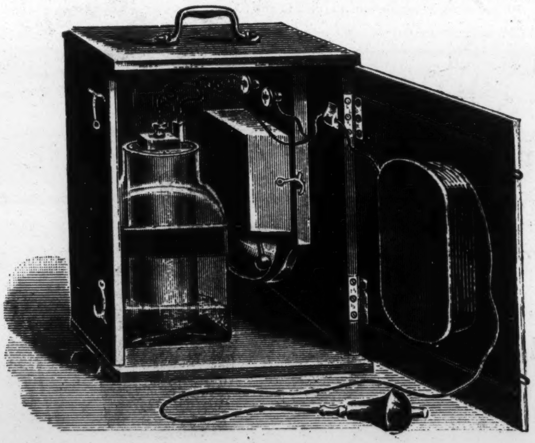

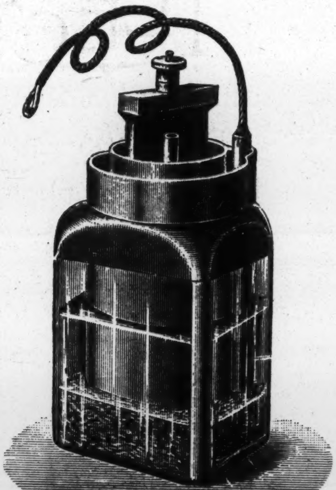

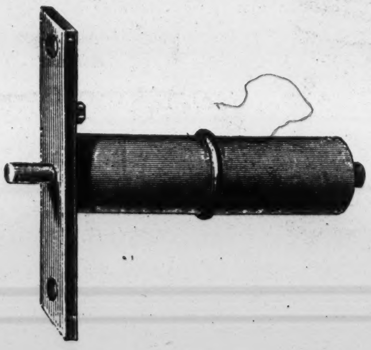

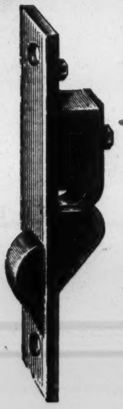

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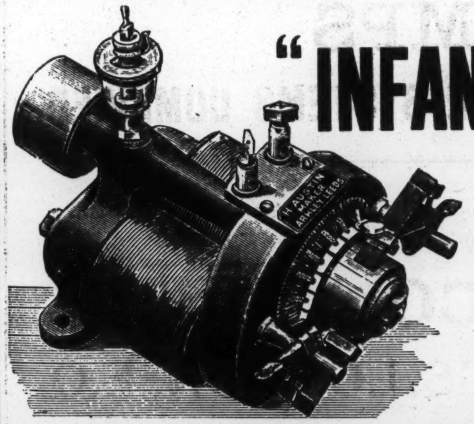
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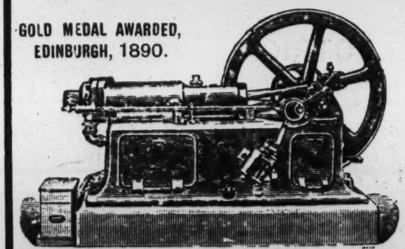

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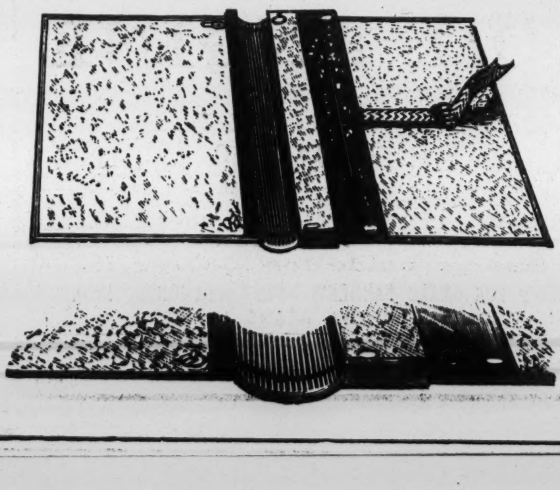

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